Firearms Finishes and Engraving

SONORAN DESERT INSTITUTE

SCHOOL OF FIREARMS TECHNOLOGY

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Chapter 1: Metal Polishing and Engraving

Beautifully engraved handgun by Bruce A. Gleason from the Firearms Engravers Guild of America.

Introduction

The quality and beauty of any gun finish depends a great deal on the preliminary preparation of the steel before the finish is applied. Metal coloring will not hide pits and blemishes, which will only be colored and, in many cases, will show up even more once the bluing or other finish has been applied.

Ideally, gun metal — whether new or refinished— should retain the original contours, comers, and planes, with no rounding of sharp edges or loss of outline and serial numbers. Care should be taken so that screw holes will not be funneled or otherwise disfigured during the polishing process. The texture of the steel should be smooth and even and show no tool marks, nicks, or polishing scratches.

There are four popular methods of finishing gun metal prior to bluing, plating, Parkerizing, and the like: hand-polishing, power buffing, mass finishing, an sandblasting. Of the four, the beginner should stick to the hand-polishing methods until they are thoroughly mastered. Then, and only then, should the beginner think of using a power buffing wheel on a firearm. Practice on some scrap pieces of metal. Power buffing is encouraged, but not until sufficient experience is gained to ensure a good polishing job without changing the contours of the metal being polished.

Gun Metal Finishes Through The Years

Metal refinishing seems to be the most critical task involved in restoring valuable firearms. Engravings, sharp corners, and lettering can be obliterated in seconds with a power buffing wheel if you are not careful. Deep pits in metal are difficult to remove without altering the original shape or removing some of the original markings. The methods that were used to color gun metal varied from era to era. To get an authentic finish, you must know these methods. Listed below are brief descriptions of the bluing methods used on firearms for the past 100 years.

Slow Rust Bluing. Around the early part of the nineteenth century, a modified browning process came into use that resulted in a blue-black finish, illustrated in Figure 1. This modified finish became known as bluing in the United States.

The earliest bluing solutions consisted of a mixture of nitric and hydrochloric acids with steel shavings or iron nails dissolved in them. The process used in applying the solution to the gun metal is generally known as the *slow rust process*.

In general, the slow rust process consists of polishing the metal parts to be blued to the desired luster and then degreasing the parts by boiling them in a solution of lime and water, or lye and water. Without touching the metal parts with the bare hands or otherwise letting them become contaminated, the metal is swabbed with the bluing solution in long, even strokes until all parts are covered. The metal is then allowed to stand and rust from 6 to 24 hours. The rust that forms is removed, or carded, with steel wool or a wire brush to reveal a light gray or bluish color underneath.

The surface, still free of oil, is again swabbed with the solution and allowed to rust another day. When this second coat of rust is carded, the metal beneath reveals an even darker shade of blue. The process is repeated until the desired color is obtained, which usually takes one to two weeks. Then, the parts are boiled in water for about 15 minutes to stop further rusting, and then oiled. The result is a beautiful, long-wearing gun finish, illustrated in Figure 2, that is still admired by collectors of high-quality firearms. However, the time required for this process makes it impractical for the average gunsmith unless it is used on a high-quality, double-barreled shotgun, which would make the extra hours and cost worthwhile.

Figure 1: To restore the original finish on this Evans deluxe lever-action rifle, you will have to use the slow rust bluing process.

Figure 2: This Savage Model 1912 rimfire single-shot rifle is another firearm that was originally finished with the slow rust bluing method. In fact, almost all firearms manufactured during this time period were slow rust blued.

Hot Water Bluing. The time required to obtain a perfect finish on a firearm by the slow rust process forced gunsmiths and manufacturers to seek a faster and easier process. The process developed has been called many names, such as *20-minute bluing, express bluing,* and the like, but *hot water bluing* is the generally accepted term.

Hot water bluing developed from the idea that steel rusts more rapidly when it is heated due to the absorption of oxygen. As a result, a chemical formula was developed for rusting gun metal. In the hot water bluing process, the metal is polished and degreased. Next, the metal is heated in boiling water. After 5-10 minutes, the metal parts are removed from the water and allowed to dry. The parts dry almost immediately due to the heat of the steel. The bluing solution, often heated, is then applied to the hot metal in long, even strokes. Rust forms at once on the metal. Before carding, the parts are again put into the boiling water for 5 more minutes. The first carding usually produces a light gray color on the metal parts and each successive coat deepens the color until it is a dark, blue-black color. Depending upon the metal, it can take anywhere from 4 to 12 coats to obtain the desired finish.

Hot Caustic Bluing. Around the turn of the century, the black oxide process of bluing was patented. Although it did not gain popularity in the firearms industry until later, it is now used in practically every gun shop and by every firearm manufacturer in the United States. Once the parts are polished and cleaned, the metal is boiled for 15-30 minutes in an alkaline solution. Hot caustic bluing works exceptionally well on a wide variety of steel. Another advantage of this method is that a large number of guns that can be blued at one time, depending upon the size of the tanks and the heating facilities. This method, however, cannot be used on all guns. Older firearms, like the one in Figure 3, can be damaged by the heat.

Bluing salts were introduced in dry form in the mid-1930s. When mixed with water, the salts formed a bluing solution that was then applied to the gun metal. Black oxide salts are still available today, manufactured as "Oxynate 7."

Carbonia Bluing. In the early twentieth century, Colt, Smith & Wesson, and some other firearms manufacturers, produced a bluing method known as the *carbonia process,* which produced a bright, mirror blue finish. The parts to be blued were suspended on rods inside a large, metal container. The container was partly filled with a special chemical in powdered form, and heated to 700°F while it was being rotated. As the powder fell onto the hot metal surfaces, a brilliant blue formed, considered by some to be the finest in the firearms industry. However, the process is complicated and requires considerable expense to set up. In addition, it is more dangerous to use than most methods. As a result, the carbonia process is fairly obsolete.

Parkerizing. To obtain a more durable finish than bluing, the military used a process, beginning with its Springfield 1903 service rifles,

called *Parkerizing*. The process consisted of boiling the parts to be finished in a solution of "Parko Powder," composed of specially prepared powdered iron and phosphoric acid. During the process, small surface particles on the parts are dissolved and replaced by insoluble phosphates, which are rust-resistant. The resulting finish is a gray, non-reflectant surface. Though this is less attractive than the color resulting from bluing, the hue is more practical from a military standpoint because it camouflages the gun by not reflecting light.

Plating. Nickel plating has been a popular finish for handguns and certain small parts of long guns since the turn of the century. The finish is applied by a process called *electroplating*, in which an electric current is used to deposit the nickel onto the steel surface. The steel part to be plated is suspended in a solution containing a high concentration of nickel along with a bar or sheet of pure nickel. The negative wire from a battery or other source of direct current is connected to the steel part (making it the cathode) and the positive wire is connected to the nickel bar (making it the anode). By carefully controlling the current, the nickel in the solution is deposited onto the steel. At the same time, an equal amount of nickel is removed from the nickel bar to replenish the amount taken out of the solution.

Case-Hardening. Case-hardening is the process by which soft metal parts of iron or steel can be hardened to make them more durable and wear-resistant. When these parts are properly case-hardened, the surface resists wear even better than tempered tool steel, while the soft, tough metal inside provides strength.

Color case-hardening, which adds patterns of color as well as strength, is accomplished by heating the metal in a cast iron vessel containing carbonaceous materials until it turns a cherry red color. The metal is immediately plunged into cold water. The process continues, alternating the hot and cold treatment until the desired hardness is achieved. Years ago, pulverized bones, hoofs and horns of animals, and soot were often used as an additive. Today, bone meal is frequently used. These substances change the structural formation of the metal and bind the fibers into a fine-grained mass.

Figure 3: If you used the hot caustic bluing method on this J.P. Sauer shotgun, chances are the barrels would become unsoldered. Use either the hot water or slow rust bluing methods on all old double-barrel shotguns.

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Basic Polishing

Beside keeping the metal surfaces free of oil, polishing is the most important step in obtaining a rich, velvety finish on your gun parts. Without proper polishing, you might as well forget bluing the gun and leave it as is. The coloring of the metal will never cover up pits, scratches, and the like. The surface of the metal must be perfect before the bluing solution is applied. Nothing else will do.

Many professional shops use power tools for buffing or polishing the metal parts. However, it takes lots of experience and practice to do a good job of power polishing without rounding sharp comers or damaging screw holes. The beginner should stick with hand-polishing, which will ensure that all contours, lettering, markings and square edges will be properly preserved. It takes about 12 hours to hand-polish all parts on the average rifle or shotgun. If many pits are present, it could take much longer.

Roy F. Dunlap points out in his book, *Gunsmithing*, that a hand-polished gun looks better than a power-polished one since corners and angles can be maintained with no loss of outline. An excellent final finish can be obtained on metal when hand-polished to a high degree of smoothness. Metal polished by power to the same degree of finish before bluing will not turn out as well.

The first step is to disassemble the gun completely. If you are unfamiliar with the takedown procedure, exploded views and instructions are available from various sources for most firearms. When you have no printed instructions, jot down notes as you disassemble the gun and perhaps take close-up photos of intricate parts. Then you will have some reference to follow when you are reassembling the firearm.

Wipe the parts clean, examine each for wear, and ensure that no aluminum alloy parts are present. This can be easily determined by using a small magnet. If the magnet doesn't react, then the part is nonferrous — aluminum, brass or similar alloy — and these parts should be set aside with others not to be blued. Besides the nonferrous parts, other parts not to be blued will include springs and other small elements not visible in an assembled gun.

With all pieces to be blued in one pile, thoroughly clean each one with a solvent, such as acetone. Then clamp the barrel or barreled action in a padded vise. Be careful that you do not clamp down too hard and damage the gun parts.

If some of the parts have pits, nicks, or scratches that are too deep for the abrasive paper to remove, use a 10 in. bastard file to smooth all metal surfaces. With the tang of the file in the left hand and the tip in the right hand, draw the file toward yourself over the metal surface to be smoothed as shown in Figure 4. *Draw-polishing* is used to produce a very smooth and true surface. To draw file, hold the file at right angles to the direction of the strokes. Draw filing keeps any polishing related scratches or undercuts in the line of draw.

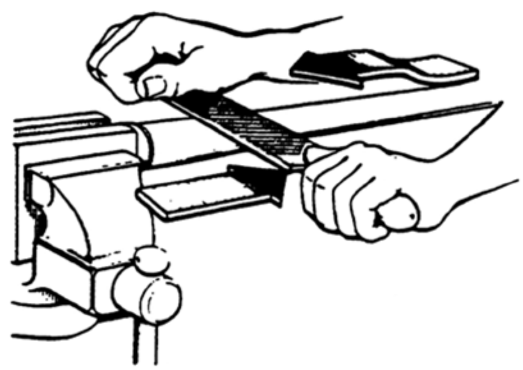

Figure 4: Draw filing will quickly remove pits from gun parts, but caution must be taken not to scratch the metal surface or take off too much metal.

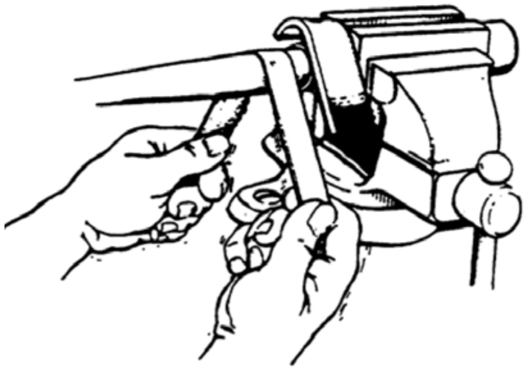

Figure 5: Use 80-grit abrasive paper to remove the flats left by draw filing. Notice that the barrel polishing procedure is similar to shining a pair of shoes.

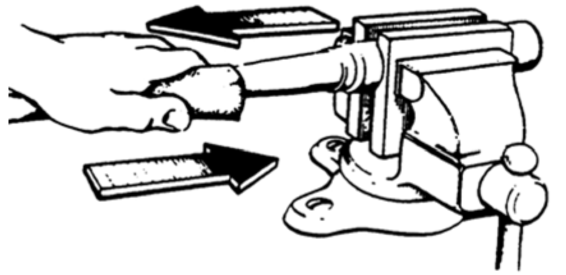

Figure 6: When draw-polishing, move the folded abrasive paper back and forth, up and down the barrel to remove the marks left from the previous cross-polishing.

The amount of pressure you use on the file is very important; too little will scratch the metal, while too much will clog the file and cause deep gouges in the metal. On the return stroke, do not let the file touch the metal; cutting should be done only on the draw stroke. In other words, with the file positioned at the most distant spot on the barrel, draw the file smoothly toward you, using enough pressure to smooth the metal without scratching it. At the end of the stroke, lift the file from the metal and arc it back to its starting position, then use pressure and draw the file toward you again. Repeat this procedure until all pits and scratches are removed. However, you must be careful not to take off too much metal, especially on thin shotgun barrels and locking points on receivers.

The barrel is now ready for cross-polishing to remove the many "flats" that will be left after draw filing. With a pair of scissors or a bench knife, cut a strip of 80-grit abrasive paper about 1½ in. wide and polish the barrel as though you were shining a pair of shoes, as shown in Figure 5. Your first few strokes will reveal the flats left by the draw filing. Continue this operation over the entire length of the barrel with the 80-grit paper until all of the flats disappear and the barrel looks like it has just been turned in a metal-turning lathe. You may have to use several pieces of the abrasive paper to achieve this polished condition.

Next cut a 1½ in. strip of the 150-grit paper and fold it a couple of times so that it fits the palm of your hand. With the open edges parallel to the bore, start polishing the barrel lengthwise. Continue polishing in this manner until all cross-polishing marks from the previous operation are removed. Instead of the palm of your hand, some gunsmiths like to use Styrofoam as a backing for the abrasive paper; the Styrofoam will mould to the contour of the barrel.

The above procedures should be repeated, using progressively finer grits of abrasive paper. Make sure all polishing marks from the previous polishing are removed before proceeding to the next finer grade of paper, and in a different direction than the preceding step.

Once the barrel has been polished, its position in the vise should be reversed and the receiver polished in a similar manner. Make certain that the newly polished areas are well protected from the vise jaws; heavy leather padding offers good protection. Then continue with the trigger, lever or trigger guard, and the like. Because of their shape, most of the smaller parts will be most adaptable to cross-polishing. Just be sure that all polishing marks from the previous grit size are completely removed before using a finer grit size.

Protect all of the newly-polished surfaces from rusting with a light coat of oil until you are ready to apply the bluing solution.

Screw heads are best polished by securing them in the chuck of an electric drill or drill press. While the screws are rotating, run a file over the head (if pitted), then complete the polishing this way with the various grit sizes of abrasive paper. In doing so, try to maintain the original contour of the screw head. The file can take off a lot of metal quickly, so be cautious.

Once all the parts are polished, you are ready to start heating up your tanks. However, if there is going to be any delay between the polishing and bluing, certain precautions must be taken. A freshly polished gun is a prime target for surface rust if it is not going into the cleaning or the hot water tank immediately. A delay of a few days or even a few hours, under some conditions, between final polishing and bluing can result in fine silver spots showing up on the gun after it has been blued. These are the result of microscopic rust spots developing while the gun is being held after polishing and prior to bluing.

POWER BUFFING

The equipment required for power buffing can vary tremendously, depending upon the amount of work that has to be done and the amount of money allotted for the equipment. Many professionals start out with only a bench grinder. Others start out with many power buffers, like the one shown in Figure 8, to save time in changing wheels.

Cloth or loose buffing wheels come in a large number of sizes and special shapes to quickly buff special contours. They are really a series of muslin discs sewn together (Figure 8). Some wheels may have only a few pieces of cloth while others may be so thick that they involve hundreds of layers. These wheels, although extremely soft, revolve at high speed and the resulting centrifugal force is constantly at work, keeping them "flat" against the surface being buffed.

When using a bench grinder, one end of a double-ended shaft contains a conventional grinding wheel, while the other shaft has a muslin buffing wheel. Therefore, the one machine can be used for both purposes. The main disadvantage is that each time a new grit size is required, the buffing wheel has to be changed. With only this arrangement, some buffing compound, and a barrel-spinning fixture, many guns can be polished for bluing at very little cost.

Figure 7: The power buffing motor mounted on a metal pedestal is the ideal setup for power buffing metal gun parts.

On the other end of the ladder is what might be considered the ideal setup for the professional gun shop. Several Baldor pedestal buffers should be installed in the buffing area of the shop. Stitched and loose muslin wheels, each containing different size of buffing compound, are installed. Number 555 gray and white polish is normally used on felt polishing wheels. Other specialty wheels might include those that have been grooved to accept curvatures of gun barrels and receivers.

The buffing room should also contain a belt sander and an assortment of belts from 60- to 400-grit, along with smaller wheels for polishing trigger guards and similar items. These can be mounted by means of a special adapter on the Baldor buffers, or used in a rotary tool. A bead blasting or sandblasting cabinet and apparatus should also be on hand in the polishing area.

Some shops even have vibrator buffers set up for final polishing. The parts to be polished are placed in barrels or drums containing the abrasive; the parts are then left to vibrate overnight. The next morning the parts will be brightly and evenly polished, ready for the bluing tank. Pits and other metal defects cannot normally be corrected in a vibrator polisher, but it does an excellent job on the final polishing.

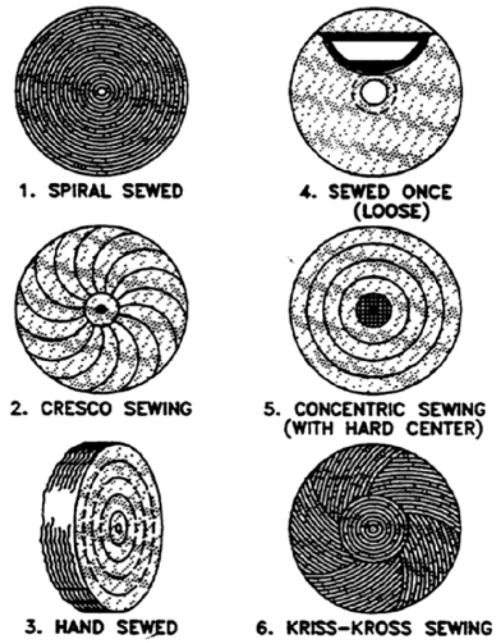

Figure 8: Various types of power buffing wheels. The spiral sewed (1) will hold uniform face longer. The cresco sewing (2) will wear down in layers. Hand sewing (3) is used on very thick wheels. Loose wheels (4) are used for high luster and will follow the contour of an object being polished. These wheels will also funnel screw holes, so be careful. Concentric sewing with hard center (5) is used for fast cutting; the hard center is used on tapered spindles. Kris-Kross (6) sewing gives almost the same results as spiral sewed wheels except the action is slower.

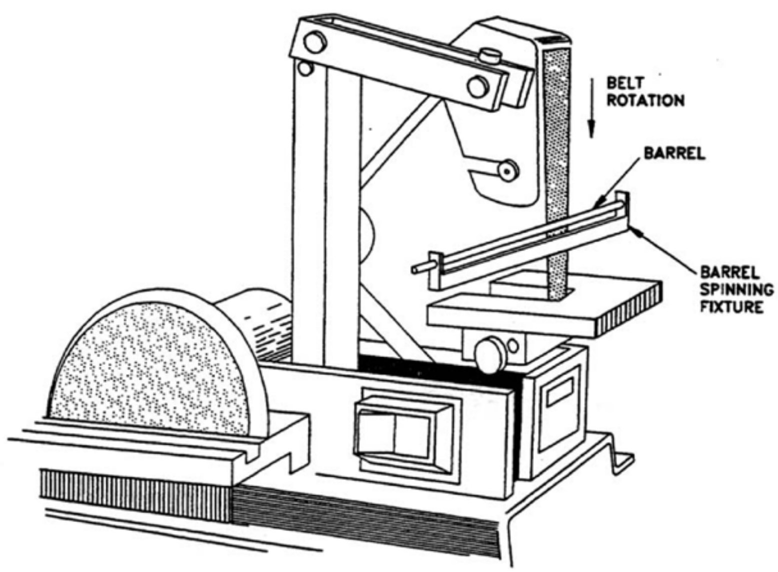

Figure 9: The power buffing room should contain a belt sander for quickly removing pits. The operation shown here is called "spinning." The barrel is positioned between centers in a spinning fixture, which allows the barrel to rotate with the sanding belt. A good, even finish is assured.

Figure 10: A sandblasting apparatus is a great help in removing rust and preparing the metal surface prior to power buffing. It is an almost essential piece of equipment, if you plan to Parkerize firearms.

To illustrate how a professional gun shop may handle the polishing of a rifle or shotgun for bluing, the following describes the normal procedure.

The firearm to be blued is first completely disassembled. On ribless single-barrel firearms, the barrel or barrel and receiver are secured between centers on a special barrel-spinning fixture (Figure 11). Until recently, most shops made their own fixtures out of lengths of pipes, fittings, and lathe live centers. However, in recent years, a fixture has hit the market that can be highly recommended: the barrel spinner manufactured by Clymer Manufacturing Co., Inc. This spinner is lightweight and can be purchased for a reasonable price, in fact, probably for less than you could make yourself. Clymer is a well-known name in gunsmithing circles due to its excellent chambering reamers.

Once the barrel is positioned between centers in the spinning fixture, and depending upon the condition of the surface, the barrel is then placed against a polishing wheel or belt and allowed to spin as the barrel is worked up and down along the face of the polishing wheel. If the barrel is pitted, the gunsmith will normally start out with the belt sander, which will cut a lot of metal quickly, and then progress down to about size 320-grit, again on the belt sander. However, for the master mirror shine, the work should be taken down to 555-grit.

Other parts are polished in a similar way. Receivers and tangs, for example, are usually held in the hands and worked in a circular motion across the buffing wheels, first in one direction and then another. When polishing, be careful not to polish out serial numbers and other lettering that is found on the typical firearm. Make sure that all corners are kept sharp and not rounded, and that the original lines of the part are maintained. If in doubt in a particular area, go to hand-polishing.

One of the more common faults with power buffing is the funneling of screw holes. Even experienced polishers will have this happen if the holes are not protected. Many shops keep a set of extra screws for most firearms to be inserted into the vacant holes. For holes in the receiver that are not threaded, use spring clips or locknuts to secure the screws in place while polishing.

In general, power polishing entails starting with the coarsest grit and polishing the surface of the metal in a given direction. With the next finer grit on a different buffing wheel, polish at 45° angles to the first pass. By following this procedure through the finer grit numbers, the final

Figure 11: A barrel spinner is useful in polishing.

surface is unequaled for quality and perfection. There are many different ways to obtain good results. Experiment until you find one method that suits you the best.

The following is a step-by-step description of the methods one gunsmith uses to prepare the metal for rebluing a Savage .22 single-shot barrel/action:

1. The first step is to disassemble the barrel/action completely.

2. The first polishing pass is made with stitched muslin wheels using 140-grit polishing compound. The barrel is held at a 45° angle to the bore and all old blue and rust pits were polished away. The lettering is not polished.

3. The next pass is made with loose muslin wheels using 240-grit. The barrel is held so that polishing marks with the 240-grit polishing compound are at a 90° angle to the 140-grit polishing marks. This pass completely removes the polishing marks made by the 140-grit compound. The lettering is not polished.

4. The last pass is with 400-grit. First, the lettering is polished using a hard felt wheel. Then with the loose muslin wheel, the barrel is held with the bore at a 90° angle to the polishing wheel and polished from one end to the other, turning the barrel slightly as each end is reached until the whole surface is polished.

Before beginning any work on the metal buttplate for a rifle, the metal is first inspected to evaluate the condition of the engraving and lettering and the severity of the blemishes that are to be removed.

In evaluating this buttplate, it is found that the engraving needs to be recut before polishing to prevent any loss of lines to the engraving.

Once recutting is completed, draw filing is used to remove deep pits in the metal. Avoid the engraved area and maintain proper contours. Once draw filing removes all the major blemishes, the surface is hand-polished using 180-grit in the opposite direction until all previous lines and marks are removed. This process is repeated — first in one direction and then in the other — using finer grit abrasive cloth until all previous lines and marks are removed.

While polishing or draw filing, it is important that all screw holes are maintained at the proper taper and that the holes do not become funneled. Sometimes screw holes become funneled due to improper installation of a screw or poor polishing. When a screw hole is funneled to the point that it is bad, the hole must be widened (retapered) and fitted with a new screw with an oversized head machined to match the new taper of the hole.

The polishing on the buttplate is complete after using 500-grit paper, 600-grit wet paper and finally 1000-grit abrasive paper with oil. At this point, the metal is ready to be engraved and blued by any of the various methods.

Figure 12: Many modern firearms use aluminum alloy parts. Special care must be taken when polishing these parts for refinishing.

POLISHING ALUMINUM

First of all, you must realize that there are many different aluminum alloys and also many tempers (hardness) of those alloys, and they all respond to polishing differently. As a result, polishing time, technique, and results will vary from alloy to alloy (Figure 12).

The basic procedure is as follows: Sand as needed to remove scratches, machine marks, and such, finishing up with a worn, greased 400- or 600-grit belt if power sanding or 600-grit wet-or-dry (used wet) if hand sanding. Clean the piece thoroughly to remove any traces of sanding grit and grease. This step is a must. Just a wipe with a cloth is not enough. Use solvent or detergent and get any grease and grit residue off or you will end up with scratches later on.

Begin polishing with 555-grit black compound on a stitched muslin wheel with about a 1 in. wide face (group 3/8 in. wheels together). The 555 black compound will take out the sanding scratches and give the aluminum a nice glow. Depending upon where the piece will be used, and how hard an alloy you are working with, it might be possible to stop after 555 black. For harder alloys and pieces that will be highly visible, change to a 1 in. wide, stitched muslin wheel and 555-grit white compound. This will change the color from a glow to a bright chrome-like shine. For a final touch, use a loose muslin wheel, lightly loaded with 555 white compound.

Here are some "Do's and Don'ts" to improve your final results:

- Don't skip grits as you work through the sanding process.
- Don't press the work hard into the buffing wheel. Doing so will build heat in the workpiece and the polish. The result will be streaks of polish deposited on the workpiece. Use a light touch.
- Don't overload the wheel with polish.
- Do clean your wheel with a cleaning brick and reload frequently. Minute bits of aluminum will gradually mix with the polish and build up a glaze on the surface of the wheel. If glaze is not removed, you will end up polishing with aluminum residue instead of polish.

Power Sanding Equipment. The following also applies to disk, belt, or orbital sanders. You must apply belt grease to the last grit. There are special belt greases available; many stick-type tapping compounds are also recommended as belt greases. Light greases like Lubriplate work well and, in a pinch, you can even apply some 555 white to the belt, disk, or sheet to act as a grease. Why? Power sanding generates a tremendous amount of surface heat and this heat causes aluminum to oxidize instantly forming a hard, oxide coating. Polishing compound 555 black cannot cut through this layer easily. The wheel will drag and pull and the resulting surface will look splotchy and uneven.

SANDBLASTING

Bead blasting or sandblasting gun surfaces is becoming more and more in demand. The process offers an excellent way to polish thin, pitted areas such as magazine tubes on rifles and shotguns where the metal is too thin to buff out the pits. The pits will remain, but the matte, non-glare finish that results from bead blasting will not make them stand out, as they would on a highly polished surface.

The sandblasting apparatus shown in Figure 10, is ideal for the professional shop, but will cost about $1,000 plus the cost of a compressor. However, there are also portable sandblasting machines, like the one shown in Figure 13, that are relatively inexpensive — less than $250.

Figure 13: Here's a good sandblasting device for both the small and large gunsmithing shop. Everything needed is included except an air compressor.

They will do any pressure/abrasive cleaning, using silica sand, steel grit, aluminum oxide, glass beads, pecan shells, or detergent and water. The most expensive item needed for sandblasting is an air compressor, which will run from $500 to $2,000 or more. For indoor use, a sandblasting cabinet is needed to hold the abrasive. These are usually provided with a glass door and electric light to enable the operator to view the work as it is being cleaned. The cabinet also should contain a pair of sandblasting gloves so the operator can hold the various objects as they are being worked on.

POLISHING SMALL PARTS

Inside radius polishing of trigger guards, magazine tube rings, and similar gun parts often requires much time because of the varied sizes and intricate shapes involved. A rotary tool with small revolving polishing disks is one way to solve the problem, but when many polishing operations are required, it is most beneficial and cost effective to install a permanent setup on a spindle polisher.

An effective unit can be made from a medium-duty, universal motor with a 1/3 horsepower rating. It may be a single-end shaft model with an output of 1725 to 3450 RPM. It is preferable to have a resilient mounting system to limit vibration and should have no restrictions on its mounting position. Because of its intended function, the motor should be dust-resistant and drip-proof. The shaft should be prepared to accept a ½ in. keyed chuck, which will greatly facilitate changing mandrels and specialized polishing equipment.

A belt-driven spindle/grinder/polisher is shown in Figure 14. Note the spindle chuck on the right-hand shaft. This is designed to hold small polishing wheel mandrels for polishing the inside radius of gun parts. If a motor shaft is used, the setup can be enhanced by using a motor-mounted rocker control switch, a reversing switch, and a variable speed control. These additional features greatly expand the unit's flexibility but are not mandatory. A split-shaft mandrel is sometimes used to hold polishing flaps of various types and grit sizes, as shown in Figure 15.

A 1 in. belt sander like the one shown in Figure 16 is another power tool ideally suited for polishing small parts. The unsupported belt spans can be used to contour and polish irregularly shaped parts. Using the table in conjunction with the backed-up area of the belt, flat and square profiling may be accomplished. Controlled radius polishing is made possible by using the exposed upper carrier wheel with more than 40 percent of its circumference available for profiling and polishing.

Figure 14: A spindle/grinder polisher has many uses in the gun shop, especially for polishing the inside radius of trigger guards, magazine tube rings, and similar gun parts.

Figure 16: Typical 1 in. belt sander. The narrow belt is ideal for polishing the inside radius of small gun parts.

SUMMARY

Regardless of the type of finish you intend to apply to the gun metal—bluing, Parkerizing, browning, etc.— the metal must be properly prepared to accept the finish. Sand or bead blasting is a quick method that leaves a dull matte finish on the surface. However, polishing and buffing is the most popular way to prepare metal to accept the desired finish.

Cloth or loose muslin buffing wheels come in a number of sizes and special shapes to buff practically any shape of metal object prior to coloring or plating. Most are extremely soft, but when revolving at high speed (from 1700 to 3600 RPM) centrifugal force keeps them "flat" against the surface being buffed, permitting a relatively great amount of pressure to be applied.

Figure 15: A split-shaft mandrel is suited for using abrasive flaps for polishing the inside radius of gun parts.

Depending upon the size of the buffing wheel, it may be used in a small hand grinder (rotary tool) for polishing small gun parts, or on a large double-shafted motor, or on large revolving shafts containing many buffing wheels. However, the most practical size for shop use is about a 1 hp, double-shafted motor that can contain two buffing wheels — one on each shaft end.

What is known as a packed buffing wheel is sometimes used for color-buffing nickel, gold, and silver. It is formed by placing cardboard disks of smaller diameter in between the cloth disks.

Pieced buffing wheels are made of remnants smaller than ordinary full disks. These are held together by continuous spiral stitching over the entire surface, which results in a wheel that is somewhat more unyielding than buffing wheels assembled by other means.

The form of sewing on a buffing wheel is most important, as this determines the hardness of the wheel in most cases. The stitching can be spiral, crescent, radial, or other — each of which has its particular use in certain buffing applications. The speed of the buffing wheel is also important. The rule of thumb is the larger the wheel, the slower the speed. That is, the larger-diameter wheels should operate at a slower RPM to acquire the same speed in feet per minute of the smaller wheels.

In general, the gunsmith pulls the parts upward against the wheel using pressure; the amount of pressure depends on the particular metal and how easily it cuts. Very little pressure in polishing is needed for any metal except steel. For removing pits in the surface of the steel, the polishing wheels cut more quickly if the part is moved in a circular motion and up or across the wheel. If there are deep pits, it is usually best to cut these out with a belt sander using progressively finer grit sizes until the metal is smooth. It can then be finished on the buffing wheel.

When polishing round, hollow objects, such as a gun barrel or magazine tube, much time can be saved by using a spinning fixture. When using this fixture the finish will also be smoother with practically no visible abrasive marks when taken down to size 400-grit buffing compound.

POLISHING PRECAUTIONS

Although it is a normal practice in gun shops, using the lathe for polishing and grinding is not recommended. Under such conditions, fine, abrasive dust gradually finds its way into the lathe bearings and eventually causes trouble. This dust also accumulates on the lathe ways and can scratch them, which affects the lathe's accuracy.

When buffing, always wear a face mask and have adequate ventilation. It is also advisable to use a vacuum tool rigged to the wheel guard to carry off dust that forms from the buffing and polishing operation. A pair of leather gloves is also essential to protect the hands from wheel burns.

The operator must avoid sharp edges on objects to be polished. If caught just right, a buffing wheel will rip a piece from hands instantly and sling it against the floor or across the room with great force. Obviously, this can damage the workpiece and people who might be in the area. Never buff a gun part that contains wires such as those used for hanging the parts in the bluing solution. Always remove the wires before buffing. If the wires are not removed and become entangled in the revolving shafts, and are near your hands, the force of the wire wrapping around the revolving shaft can cut off your fingers.

Mass Finishing

Many of the firearm manufacturers—and even some private gun shops — use barrel tumbling and vibratory finishing methods to prepare metal parts for bluing. Mass finishing stands alone in its ability to perform many processing steps at once. Media compositions and shapes, along with improved equipment, have evolved to the extent where it is now possible to perform as many as ten simultaneous operations on gun parts.

A vibrator sanding drum large enough to hold a complete gun can be very costly, but many gunsmiths have had luck polishing small pans with a vibrator designed to polish brass cartridges for reloaders, like the one in Figure 17. If these are

Figure 17: Vibrator cartridge-case polishers are being used in gun shops for polishing small gun parts prior to bluing and are available at Midway USA. Be selective in choosing the appropriate polishing medium.

used, remember that the walnut shell abrasive that comes with them is not good for polishing steel parts; it is good for brass, but not steel. A polishing medium with more cutting abrasives should be used. These are available from a local body shop supply house or an industrial supplier.

The workpieces might be, for example, a batch of magazine tube rings for a .22 caliber semi-automatic rifle. In a single finishing operation, the medium can remove die marks, improve metal fatigue life, and impart a high-luster finish. Performing each job separately would obviously be uneconomical by today's metalworking standards. This is why the mass finishing process is growing at a rapid rate.

Important to the success of mass finishing is the consistent finishing action, which guarantees uniformity of surface finish of every workpiece in the work load. Proper selection and control of all elements involved in the process—equipment, medium, compounds, water, and time cycles—must be synchronized correctly for the best results.

Conventional mass finishing equipment can be categorized by the purpose and function it performs according to the following:

- Vibrators should be operated at the frequency and amplitude that provides best movement of the work load.
- High-pressures-force equipment should be set for the proper G force for the given application. G forces of 25 or greater are recommended for the fastest surface removal, 10 to 20 Gs for intermediate action, and 5 Gs for polishing.

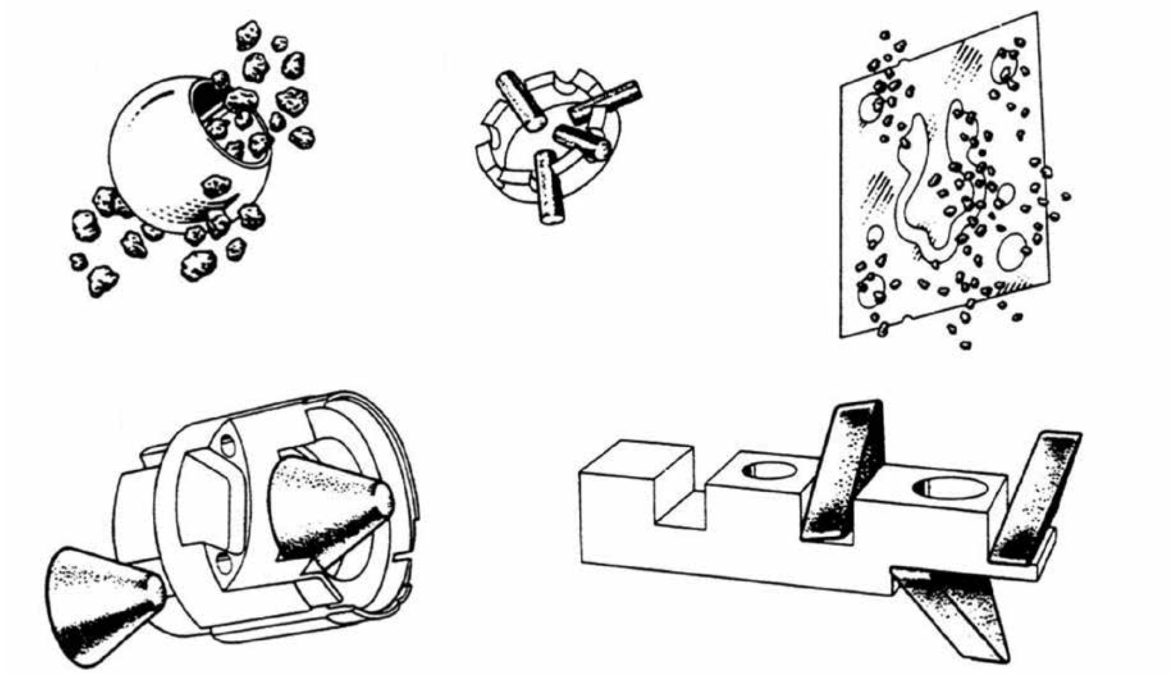

Figure 18: The abrasive medium should match the job. Here are just a few of the many shapes of media available. They are designed to reach in every crevice and slot, and will do a fine job of polishing with the least amount of effort.

MEDIUM DEVELOPMENT

During the past 30 years, rapid development in equipment and medium technology improved compositions for the more aggressive vibrators and high-pressure-force equipment.

Preformed, ceramic-bonded shapes such as triangles, stars, spheres, cylinders, and diamond shapes have appeared in the marketplace. Since their inception, a large variety of these shapes and compositions have been developed to finish parts with a minimum amount of wedging problems (Figure 18). Ceramic preforms are now available with compositions of aluminum oxide, silicon carbide, natural abrasives, or without any abrasive content.

Within the past 20 years, medium manufacturers introduced lightweight, preformed resin-coated media to remove burrs, flash, gates, and parting lines while maintaining smooth micro-inch finishes on soft ferrous and nonferrous parts. This process is often referred to as producing preplate finishes and is most often used on zinc and aluminum die-castings.

MEDIUM SELECTION

The scope of mass finishing is large and diverse, requiring a number of medium specifications to accommodate the many finishing requirements. Manufacturers and suppliers are well qualified to advise users on the proper recommendations for finishing their products.

Because of the many considerations in selecting the type of abrasive medium to fit a particular job, it is important that users familiarize themselves as much as possible with the different abrasive materials available — what they are and what functions they perform under various conditions.

The first prerequisite is to review the workpiece's material, shape, size, and weight. Also determine the part requirements: removal of burrs, sharp edges, tool marks, flash, grinding lines, and heat-treat scale, forming, producing surface finishes to specific requirements, and improving metal fatigue life.

A systematic approach should be used in selecting the composition, shape, and size of abrasive

to process a particular part. The abrasive compositions are generally classified as aggressive, intermediate, or mild acting. Aggressive abrasives are used when maximum stock removal is required. Intermediate abrasives are used when a combination of stock removal and smooth surface finishes are necessary. Mild abrasives are employed when minimum surface removal and high luster are desired.

With synthetic abrasives, the aggressiveness can be controlled accurately. Crystal structure and density will determine the aggressiveness of the random-shaped abrasive medium. The type of abrasive, the amount of abrasive in relation to bond, abrasive density, and bond hardness determine the aggressiveness of the ceramic and resin-bonded medium.

Composition. Those familiar with grinding operations usually associate the use of aluminum oxide with ferrous metals and silicon carbide with nonferrous metals. But this is not true in mass finishing. Aluminum oxide is used in most applications, regardless of the type of metal being processed. Other abrasive materials used include silicon carbide, corundum, quartz, pumice, and garnet.

Shape. The shape of the medium to be used is determined by the shape of the part being processed. Slotted parts are best finished by triangular-shaped media. Parts with holes or rounded areas would be best processed by round-pin or spherical-shaped media. In most instances, stampings or parts that have plain basic shapes with few areas for the medium to lodge in are best processed with random-shaped media.

Size. The size of the medium to be used is determined by the size and weight of the part being processed. The larger the part, the larger the medium. The reason for this is to displace the weight of the parts, which keeps the parts in a uniform mixture and prevents nicking. The areas of the part that require processing also determine the abrasive medium size. If the area is restricted or not easily accessible, it is necessary to use a medium small enough to reach in this area.

Another very important consideration in selecting the best size and shape of medium is the ability to separate the medium from the parts when the job is completed. Abrasive size is not too critical when processing ferrous metal parts because they can be separated magnetically. But with nonmagnetic parts that require screen separation, medium size determines the ease of separation.

Another factor in selecting the size of medium is the amount of metal removal required. The larger the size of the abrasive medium, the more weight and energy generated and, consequently, the greater amount of metal removal. Therefore, the amount of metal removal can be controlled simply by selecting different sizes of media.

There are additional benefits in knowing how much metal can be removed by the various compositions and sizes of media. A very important benefit is the control of dimensional tolerance. Today, dimension is so important that it is not uncommon to see dimensions controlled to millionths of an inch.

The type of machine being used also dictates medium selection. It is quite common to use the most aggressive abrasive medium in tumbling barrels and the more durable medium in vibratory and centrifugal machines. All of the abrasive composition can be used in all the various types of machines.

Frequently, a manufacturer's equipment capacity and production requirements influence the abrasive composition used. If a manufacturer's work load exceeds the machine capacity, the most aggressive abrasive medium available must be used. This way, the mass finishing time cycle can be kept to a minimum and maximum production can be obtained from the machines.

Figure 19: Some hard-to-polish gun parts that are ideally suited to vibrator or tumbler polishing.

Some manufacturers have an excess of machine capacity over production volume. This allows the use of a more durable, less aggressive abrasive medium. The time cycles are increased, but these manufacturers have the advantage of a lower cost per finished part because of a longer medium life.

COST SAVINGS

The reason a manufacturer turns to mass finishing is to eliminate the necessity of handling each individual part, and a finish not obtainable by any other method, at a considerably lower cost, is obtained (Figure 19). The amount saved depends, naturally, on the cost of the abrasive medium and compound used. From a cost standpoint based on lowest cost per pound of medium (which is also affected by medium weight and wear rate), the following guidelines are recommended:

- Use a random-shaped medium as first choice, provided it does not lodge in the part.
- If the part presents a lodging problem, then the second choice is the preformed ceramic-bonded medium.
- If the part cannot be processed with either of the first two materials, use a preformed resin-bonded medium.

WET FINISHING

Water levels are extremely important in industrial mass finishing because a high percentage of all operations are done with wet solutions. In rotational barrel finishing, low water levels are recommended for fast cuts. For polishing, the water should be level or slightly over the top of the mass. With vibratory equipment, "flow-thru" water systems should have a constant water stream to produce optimum results. Low water levels are recommended in a "captive" solution where there is no "flow-thru" system.

The water level should be over the top of the workload when using high-pressure-force equipment because the water helps dissipate the heat generated by the high frictional forces. Low water levels — just high enough to form a muddy mixture—are recommended for spindle machines.

Abrasive or grinding compounds are finding wider use because they can increase the cutability of the medium charge and because they can be used in self-tumbling applications (part on part, without a conventional-type medium). These compounds are classified as either abrasive or nonabrasive. The nonabrasive compounds, for example, come under three general classifications: alkalis used as rust inhibitors, descaling compounds used for removing heat-treat scale, and burnishing compounds for imparting color and luster to parts.

However, for general gun work, most gunsmiths seldom use mass finishing exclusively. Gun barrels, for example, are normally polished on a spinning fixture, using either a belt sander or polishing wheel. Small, hard-to-polish parts, such as triggers, pins, and the like are often placed in a polishing medium inside a tumbler at night, and the next morning they are ready for the bluing tanks. Others use the mass finishing system exclusively, except for removing pits. Areas containing pits are first draw filed and polished in a conventional manner. Then, all parts are placed in a vibratory barrel and allowed to vibrate for 6 to 12 hours. They are usually ready for the bluing tanks after this time.

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Metal Engraving and Jeweling

Why do gun collectors and authorities hold engraved guns in such high esteem? A plain gun shoots just as well. Some trap and skeet shooters who compete with engraved guns (which are worth, in some cases, thousands of dollars), feel that the personal pride that goes with using a finely engraved gun promotes a positive mental attitude that's important to winning.

As for the serious collectors and gun experts, they know that engraving often separates the garden variety piece from the highly prized collector item, especially on American-made guns where engraving is less common than on European guns. Engraving not only increases the value of a gun, but also shows appreciation for craftsmanship and artistic ability, or in a word, *quality*. European engraving schools are four-year courses. Then, if the graduates are talented, they may reach the status of "Master Engraver" in 10 or 15 years of hard work. So, do not expect to become a gun engraver overnight, or know all there is to know in one lesson.

The main purpose of this lesson is to introduce you to metal engraving as applied to firearms — pointing you in the right direction should you desire to pursue the venture further. More importantly, you will be able to discuss the various types of engraving with your customers and be able to recognize the quality of workmanship on firearms that cross your counter.

ESSENTIAL OF GUN ENGRAVING

Metal engraving may not be the oldest profession known to mankind, but every engraver can trace the ancestry of the trade back 5,000-6,000 years. Examples of the engraver's skill, in the form of seals or signets, have been credited to the Babylonian civilization as far back as 3800 B.C. The arms engravers' branch of the art began with various decorative symbols engraved upon the earliest metallic weapons, such as knives, swords, and spears.

One of the earliest examples of engraved weapons is a bronze dagger on display in a museum in Athens, Greece. This weapon, decorated with

Figure 20: Beautiful example of engraving by Jeff Knodle, member of the Firearms Engravers Guild of America.

gold and silver inlays of spears and bowmen fighting lions, has been dated to about 1500 B.C.

The earliest firearms were also the subject of the engraver's art, with examples dating back to the fifteenth century. Though long obsolete as practical weapons, early engraved firearms are prized possessions for individuals as well as museums who display their embellished matchlocks and wheellocks as forms of high art.

Today, many modern guns can stand beside the early arms as works of art because of the knowledge, skill, and dedication of contemporary firearm engravers (Figure 20). Gun engraving is not a dying art. It is alive, well, and flourishing through the efforts of men and women whose work can justly stand beside that of the old masters of the art.

Figure 21: The gunsmith who does metal engraving is not limited to just guns; knives, metal powder flasks, and other items like this hand tool can also be engraved. Engraving done by Catharine C. Kennedy, member of the Firearms Engravers Guild of America.

METHODS AND TOOLS

The methods and tools used by the gun engraver are fairly simple in concept and have changed very little over the centuries. In fact, if any of the great gun engravers of the last century —Louis D. Nimschke or Gustave Young, for example — were to step out of a time machine and into a modern engraver's shop, they could probably pick up a tool and start engraving with little change in procedure. The tools of the gun engraver are the most simple things that can be imagined; like drawing, where the only tool needed is a pencil, the work is done mostly relying on skill and talent rather than sophisticated equipment.

In addition to engraving ability, a metal engraver finds it useful to have certain other supplementary qualifications. One of these is a basic knowledge of metallurgy.

Different makes and models of guns are made of different types and variations of metal. Since a metal engraver is not limited to just guns, it is important to know about metals used for bottles, flasks, and knives, as shown in Figure 21.

Another valuable asset is a knowledge of tool and die making. Most gun engravers make or shape to their own specifications at least half of their own tools. So a basic knowledge in this area is extremely useful. A third skill is a good basic knowledge of general gunsmithing because the engraver is going to have to disassemble and later reassemble the guns being engraved.

The basic tool of engraving is usually called a chisel, a small piece of tool steel specially sharpened for the desired cut and sometimes having a wooden handle. The chisel engraves by tapping it with a small hammer called a chasing hammer. Engraving is also done with a tool called a *hand graver, burin,* or *bulino*, depending upon the engraver's background.

Gravers are made of hardened tool steel — hard enough to cut all but ultra-hard alloys and case-hardened steel. These simple tools can be compared to the paintbrushes of an artist. Like painters' brushes, gravers come in different sizes and shapes, and have different names.

There are square, flat, round, and knife gravers, among others, all designed to do specialized jobs (Figure 22). Most metal engravers shape their tools to fit their own special needs. Also, by having this knowledge, engravers are qualified to sharpen their tools when they become dull — a continuing necessity.

One of the most used cutters is the *square graver*. Its end is square, as the name implies. One corner is used to make triangular grooves. The basic outlining you see in gun metal scrollwork is done mostly with this instrument. The square graver is also the primary tool used to cut cross-hatching for shading and shadow effects. The square graver can be either pushed across the metal by hand or with a small chasing hammer. The more need there is for precision, the more likely the hand will be used instead of the hammer.

An equally used tool is the *flat graver*. It is shaped somewhat like a common chisel except that its cutting edge may be only 1/32 in. wide. This graver is used to cut away material around miniature

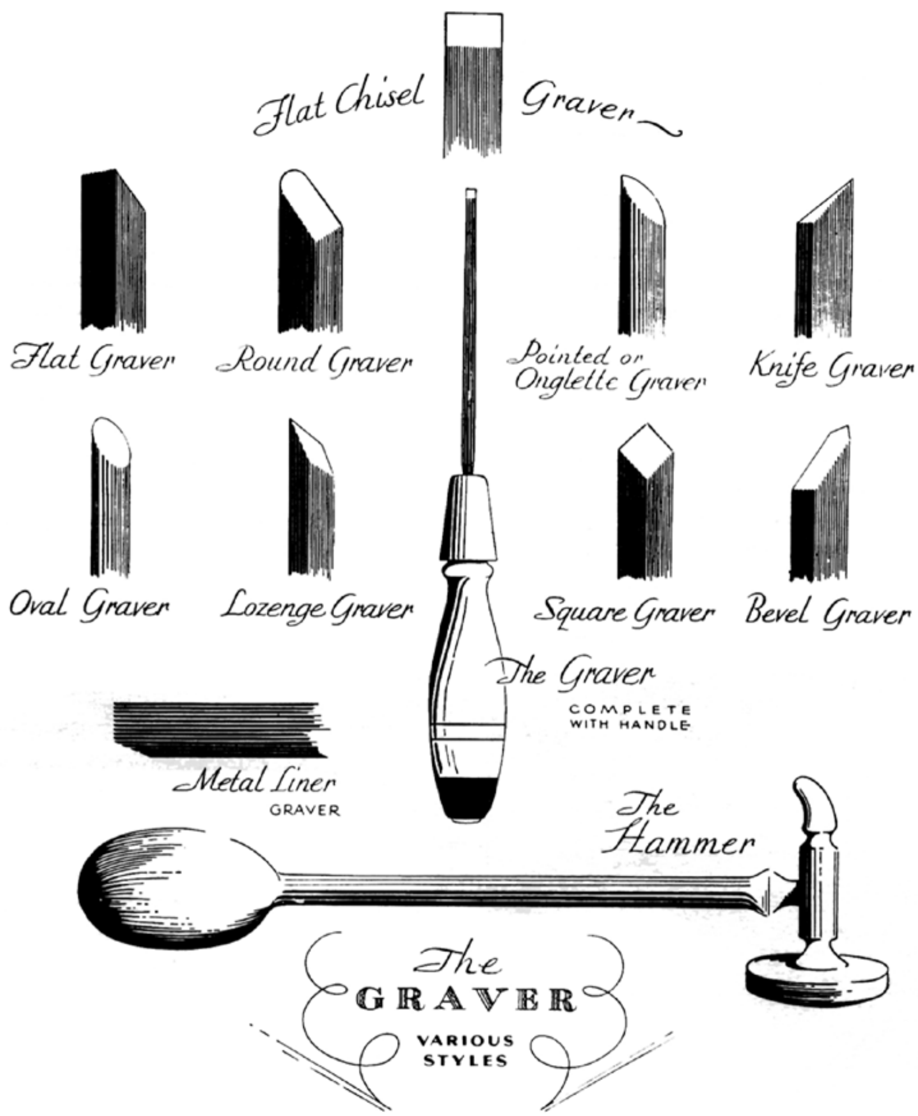

Figure 22: The basic tools of the gun engraver are simple. However, final success depends on the vision and skill of the most important tool of all – the gun engraver.

figures of animals, leaves, etc., and for molding and modeling these forms to a fine finish.

A chisel graver is also often used. It is similar to the flat graver but with a wider cutting edge. It is used for gross removal of metal so as to lower the background away from foreground elements.

The other gravers are used less often, but they have specialized functions. The *knife graver* is used to cut a special type of line. *Oval* and *round gravers* often come into use on curved surfaces, like the top of the receiver on the Colt Woodsman shown in Figure 23. There are other gravers used for such jobs as matting and inlay work.

An important complementary tool is the engraving block, or vise. This is a heavy, spherical vise for holding the piece of metal being engraved. It usually rests on a doughnut-shaped pad of leather. By using such a vise, the engraver can move the piece to almost any desired angle. More important, it can be moved during the engraving process. Thus, when carving sharp bends in a scrollwork pattern, the engraver does not have to make large and potentially inaccurate movements of his body. The workpiece, held in the rotating vise, is merely moved to the desired position, leaving the graver almost stationary. This is a great aid when making precise cuts.

There are also a number of other tools that are useful to have around. One of these has to do with eye saving. Obviously, when engraving outdoor scenes on surfaces as small as an action sideplate, or even engraving a screw head, the eyes are going to get a considerable workout. When putting in cross-hatching lines for shadow effects, the line spacing may be only a few thousandths of an inch. An engraver normally uses a jeweler's loupe with a single magnifying lens — usually only 2x or 3x in strength. It is not true that the greater the magnification the better the engraving quality. More important is how the elements in a scrollwork design or an outdoor scene relate to each other — maintaining the correct perspective. This is easily lost if the engraver gets too close to the work.

An equally important eye aid is correct lighting. High intensity is not necessarily the key in this case since the metal reflecting light may cause eyestrain. Instead, ample diffused light placed close to the work is the answer.

All metal engravers will also have a sketchpad close at hand. Most of the basic ideas for scrollwork and outdoor scenes come from the elements existing in nature. Thus, the gun

Figure 23: Very few tools were used for the scrollwork on this Colt Woodsman semi-automatic rimfire pistol.

engraver must record in some way these various scenes as he sees them in the woods or field - or perhaps at a local zoo. A camera is often used for this purpose. The engraving scene as it finally shows up on the gun may consist of several different images from several different trips into the field. Photographs can serve well to trigger the imagination and pull these images together.

Another commonplace, but sometimes important addition, is a *mechanical grinder*. Since the engraver makes many of his own tools, and must also sharpen them periodically, this tool is almost a necessity.

If you are starting from scratch, you will save a lot of time and confusion by buying one of the engraver's tool kits available from various retailers. These kits are designed for the beginning engravers who are still in the process of finding out which tools they are most comfortable with.

James Meek's Beginner's Kit. This kit contains point, numbers 0 and 4; square; two Momax Cobalt Blanks; flat, numbers 36 and 39; knife, number 2; and round, numbers 50 and 59, for a total of nine gravers in all. The point graver No. 4 will cut most scrolls if sharpened correctly. Fine detail is cut with 0 and 00 points, and the No. 2 knife. The square is perhaps the most widely used, for it can be sharpened as a point or a chisel. Flat and round gravers are needed for lettering on high relief work.

There are also a couple of machines for use in gun engraving that are suited for the beginner or for the quality-oriented master engraver who is production minded. One is called the Gravermeister (Figure 24) and the other is the NgraveR Electric Engraving Tool.

Gravermeister. The Gravermeister is manufactured by GRS Tools (www.grstools.com). Its power is regulated through a foot pedal, which serves the same function as the foot throttle in an automobile. Control is so precise that with the proper tool chucked into the handpiece the operator can vary the power in ranges from stipple engraving on delicate crystal to the task of hogging out metal from a steel die.

Figure 24: This Gravermeister engraving system gives each handpiece excellent range of power with perfect control throughout an expanded range of impact speeds.

Delicate speed and power control make this machine ideal for gun engraving. It moves gravers, liners, beading tools, files, and stones effortlessly whether cutting steel dies or carving and finishing delicate gold and silver inlays on quality custom guns. The alternating vacuum and pressure system does not permit the handpiece to heat as happens if operated by air pressure alone. Therefore, bright, smooth cuts can be obtained on both ferrous and precious metals.

Florentine and matte are the most common types of gun engraving finishes. Such finishes are applied with a Gravermeister tool called a liner, which is essentially a flat graver with V-shaped grooves cut into the bottom to produce parallel lines. Liners are categorized by width and number of lines per tool. The lower the width number, the narrower the tool; therefore, a #14-6 and a #18-6 would both cut six lines, but the #14 would be closer spaced because of its narrower width. Many different width and line combinations are available, but the liner generally favored by gun engravers for florentining is the #18-10.

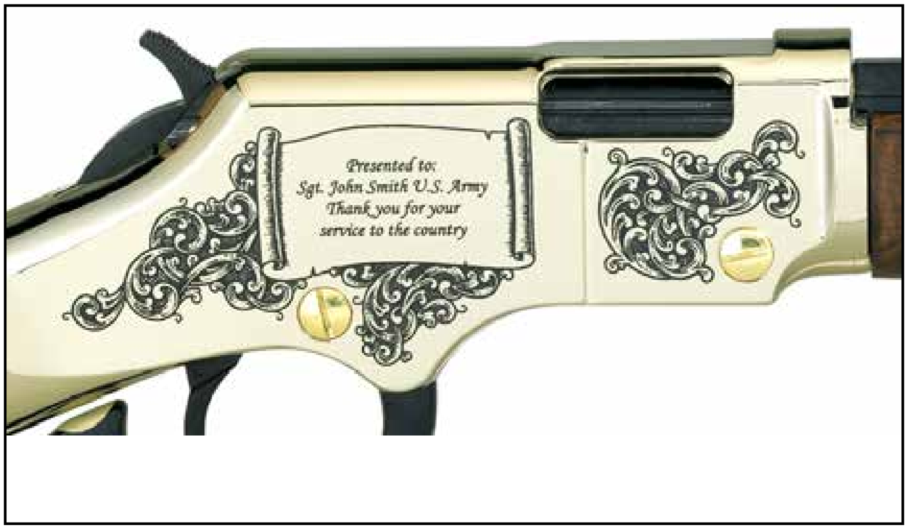

Figure 25: Many modern, custom-engraved guns are used for presentation purposes, like this gun designed by Henry Repeating Arms.

Florentining consists of cutting crossed sets of lines. First, all of the lines in one direction are cut. Then, cross lines are applied at the preferred angle — just like checkering a gunstock. A somewhat similar effect can be obtained by dragging the tip of the liner across the desired area. This action produces lines with no material removal. The stroke-speed setting and the speed with which the Gravermeister is pulled determine the spacing effect. If you drag the tool at a constant speed, increasing the stroke speed results in closer spaced lines.

The liner is sharpened the same as a flat graver: the face of the tool is held at about a 45° angle and like most gravers, should be polished after sharpening. In addition, the tip of the liner should be gently wiped on a sheet of crocus cloth to remove burrs, thus permitting polished cuts.

Using the machine is like playing an instrument — it requires practice to develop skill. Those people who show an interest in the instrument and practice faithfully start producing faster. Those who are not willing to practice do not seem to do very well. Therefore, if you decide to do any type of gun engraving — whether with hand tools or a machine — you would be wise to purchase several engraver's practice plates from Brownells. They sell inexpensively in lots of five plates, so you can practice, practice, practice for very little money.

In general, the Gravermeister is used in place of the chisel and hammer. It operates by locking the steel part of an engraver's chisel into a handpiece that is connected to a length of tubing. The tubing is connected to a motor that provides an alternating pulse of air, which activates a hammer within the handpiece. Though the Gravermeister is a mechanical device, work done with it is properly considered hand engraving because the pneumatic hammer only takes the place of the chasing hammer, freeing one hand to turn the vise.

NgraveR Electric Engraving Tool. This machine is meant to replace the hammer and chisel in the hands of the engraver, and is somewhat less expensive than the Gravermeister. Working on a unique patented mechanical power transfer system, this electric engraving tool is actually a tiny jackhammer run by a standard flexible shaft power tool using the 3:1 gear head accessory.

The flexible shaft from any flex shaft machine attaches to the engraving tool with standard

quick-detachable couplings. When the flex shaft turns, it rotates a drive shaft inside the tool, which in turn compresses a spring, forcing the striker against the tool holder. The rate of impact is completely controlled by the foot rheostat, and is variable from 300-1500 impacts per minute. The system is so well-designed that there is no noticeable vibration.

For the beginner, this electric engraving tool will start him or her cutting clean, bright lines effortlessly without the ever-present worry of accidentally skidding across the work. For the professional, the tool makes engraving easier, allowing more work to be done in a given period of time — without compromising the quality of the work.

Ray Phillips, President of NgraveR Company, put together a Beginner's Kit to be used with the NgraveR Electric Engraving Tool. Detailed instructions are included along with four gravers: No. 1 diamond, No. 2 narrow chisel, No. 12 Liner, and a 1.8 in. round blank to be shaped as needed.

Either the Gravermeister or the NgraveR is of little use without certain other tools. First of all, you will need an engraving block. One such block is offered by GRS and was designed by a master engraver who was tired of block movement when making precision cuts. This massive 28½ lb. engraving block is a stable work-holder for all engraving, including heavy cutting and chipping. This block can be used to engrave everything from the shotgun in Figure 25, to the knife in Figure 27. This block is available from Brownells.

Besides an assortment of gravers, you will need some means of sharpening them — especially if you use the power machines. A power honing tool — also offered by GRS — is ideal for this use. It is faster and easier for the beginner to learn and saves valuable time for the experienced engraver. The fully shrouded motor is carefully balanced and trued to turn the 4 in. silicon carbide stone or the long-lasting, fast-cutting 600-grit diamond lap smoothly and without wobble. The motor rotates the stone at a smooth 200

Figure 26: Set of engraving tools.

Figure 27: This presentation-grade knife features a tiger-eye insert and metal engraving by Jerome Glimm.

RPM for fast, no-heat tool sharpening. The high position of the stone gives clearance to sharpen all graver points and tip angles. The flat-top surface provides an ideal platform for combined use with the GRS sharpening fixture to maintain consistent angles.

The Graver Sharpening Fixture provides accuracy for sharpening the tools. It enables gravers to be located exactly every time, ensuring that your tool will cut the same after sharpening.

Engraving — The First Step

Most serious gun engravers agree that design is the most important factor in a good engraving job. Professional engraving schools in Liege, Belgium; Ferlach, Austria; and Gardone, Italy, all put great emphasis on being able to draw proper designs. If both the master engravers and the engraving schools attach so much importance to design drawing, there must be something to it.

Figure 28 shows one of the drawings required at the engraving school in Liege, Belgium. This school believes that the ability to draw a design precedes any attempt at actual engraving. Since a good engraving job is only as good as its design, it would therefore follow that the first order of business for the beginning engraver is to be able to draw. If you cannot draw a good design, you cannot possibly expect to cut one. There are some engravers who might disagree with this statement, but those that do usually are trying to sell engraving tools, patterns, or an instructional dvds.

Figure 28: A Belgium engraving student's drawing prior to cutting the design on metal.

The first step towards a good design is to be able to draw scrolls, since most of the engraving styles are based on a combination of flowing scrolls, in varying sizes. Start by drawing single scrolls, both right and left hand. Larger scrolls are not only easier to draw, but also easier to cut, when one gets to that point. Practice drawing these single scrolls until they are exactly right (Figure 29).

After perfecting the drawing of single scrolls, try stacking several scrolls, one on top of the other as shown in Figure 30. As with single scrolls, practice this "stacking" until you can do it perfectly. Assuming you have mastered the foregoing drawing exercise, you are ready for the next step.

Admittedly, these bare scrolls really do not look like much and the way to correct this is by filling them in with "leaves." There are many styles of fill leaves, a few of which are shown in Figure 31. Remember, take your time. Do not skip any of the steps; there are no shortcuts to good engraving. Your progress will be in direct proportion to the effort you put into this highly specialized form of art.

By this time, if you feel that your drawings look similar to the samples shown on these pages, it is highly recommended that you purchase the book, *The Art of Engraving*, by James B. Meek. It is available from Brownells, as well as online booksellers. You will also want to check out the GRS Tools website at www.grstools.com. This

company has just about everything an engraver will need in the way of equipment and supplies.

When you get to the point where you want to start cutting, acquire a quantity of soft steel practice plates from GRS or Brownells. Practice cutting designs on these first. Under no circumstances should you jump from the drawings directly to cutting on a good firearm or knife.

THE FIRST CUT

An engraved design on steel can be geometric — straight lines, triangles, circles, etc. — or it can be artistic — scrolls, floral or rose style, game scenes, etc. It is the latter type that is generally so much admired on guns. The cutting of such a design requires artistic ability and appreciation that must be inherent.

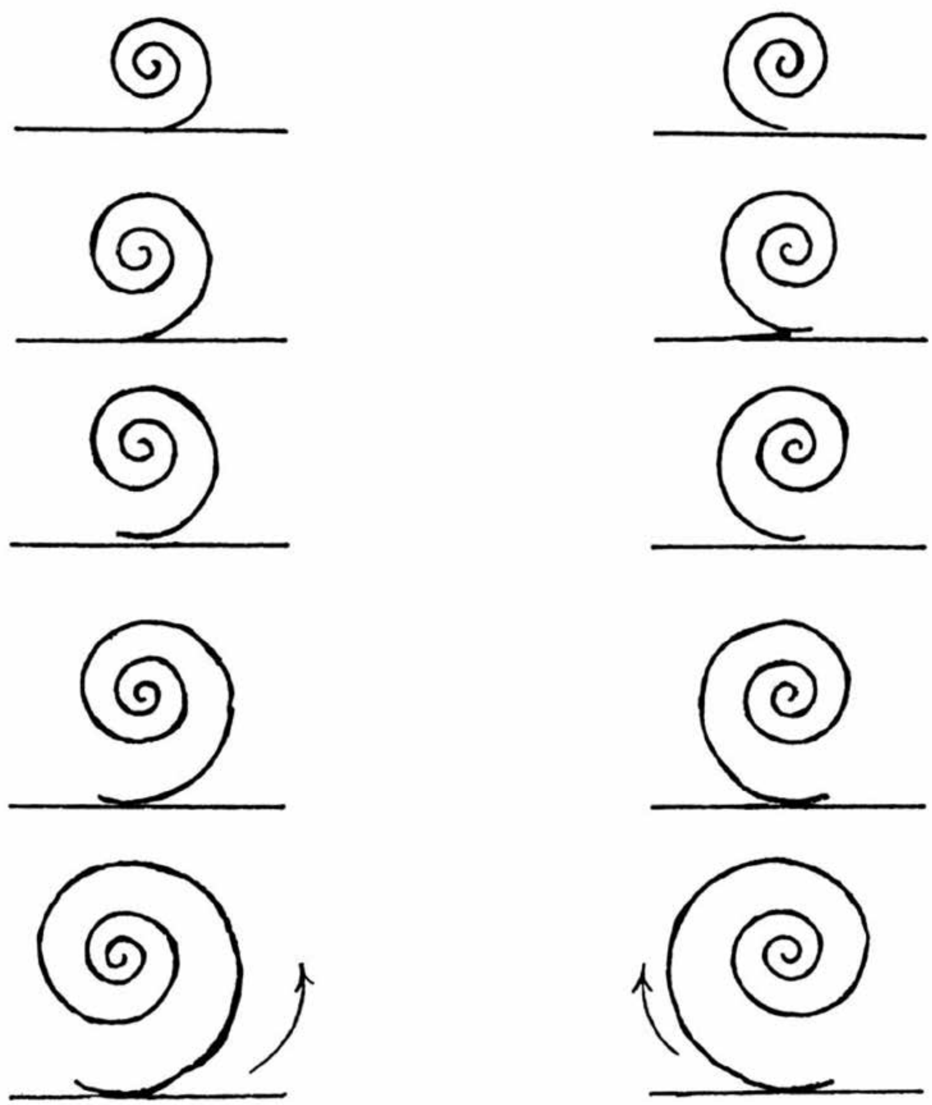

Figure 29: Draw single scrolls first. After drawing each scroll, turn the page sideways to detect any "egg shaping." Remember, the scroll is the basis for most of the designs done on guns and knives today. It is absolutely necessary to master the scroll before moving on. Keep your scrolls fairly large at first. Start from the outside and work your way inward.

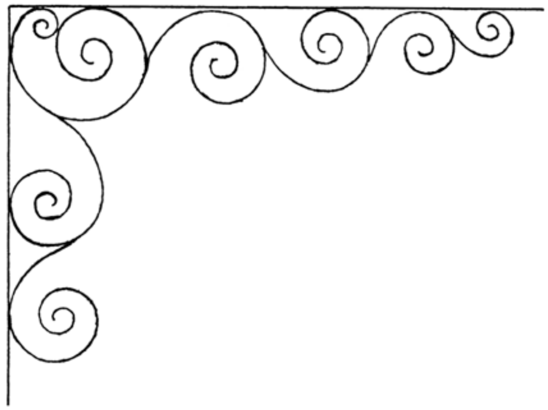

Figure 30: Once you have mastered single scrolls, try stacking them as shown here. Later on you can dress them up a bit with shading, flowering, etc.

However, you can acquire a certain proficiency in copying and reproducing designs mechanically. If talent is later uncovered, the reward will be twice as great.

The tools advised and the method of procedure outlined earlier in this lesson are not to be taken as the only ones available. Instructors will teach different methods and recommend different basic tools. As with many artistic crafts, there is no one right way; it is the end results that count.

The tool shown in Figure 32 is the No. 6 square graver, which is slightly under ⅛ in. square. Graver sizes are numbered from 0, the smallest, to 10, the largest in normal use. The square graver is used with the point of the square doing the cutting as opposed to the flat or chisel graver where the whole side is used for cutting. The graver blade (3-3½ in. in length) should be mounted in a mushroom-shaped handle with one side cut away. The cutting point of the edge of the square graver is called the face. The top edge as you look down on the tool is called the back. The graver blade as supplied from the manufacturer must be prepared and sharpened before it can be used. Unless the tool is sharp it will not cut. If it will not cut, you cannot hope to achieve any useful results.

The metal to be engraved must be smooth, well polished, and above all, held firmly. The best tool for holding the part to be engraved is an engraver's vise or block as discussed previously. Once the part to be cut is secured firmly, the graver is held in the right hand with the mushroom handle resting in the palm against the flesh lump below the little finger as shown in Figure 32. The thumb is held along the side of the tool pointing toward the cutting face. The index finger is held across the back of the tool to rest firmly upon the work — not curled around the tool. The second, third, and fourth fingers are curled around the handle to steady and support the tool. The thumb is used to give directional guidance. The palm transmits the driving power from the arm while the index finger acts as a stabilizer.

The graver should be held comfortably and firmly. Most people find it is easier to work standing than sitting. When using a swivel vise, rotate the work when making a curved cut, particularly a small, tight curve as in fine scrolls. As far as possible, cut in a straight line across the body, similar to cutting checking lines in curved gunstocks. The main objective at this point is to get the feel of the tool as the point "bites" in and starts to cut.

Dig the point of the graver into the metal and then to avoid making too deep of a cut, lower the handle end of the tool until the angle of the cut is running parallel to the surface. By varying the depth of penetration into the metal before leveling off, you will eventually be able to adjust the heaviness (or lightness) of the required cut.

To finish a cut, give the graver a sharp upward and forward flick. With practice, this motion should break off the chip or curl of metal and leave a neat, clean cut.

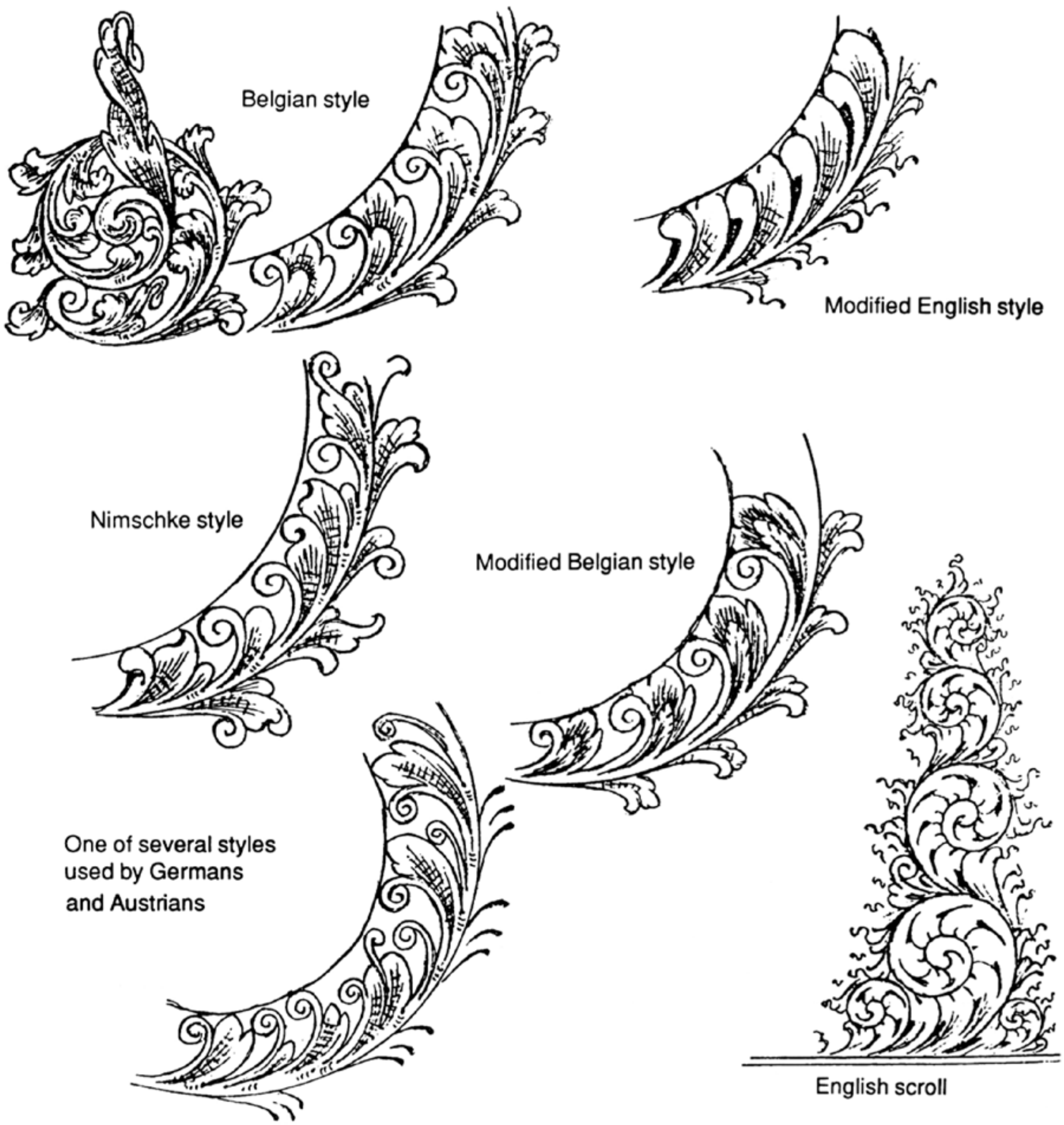

Figure 31: Different styles of fill leaves for use inside scrolls; also various types of spurs for use on the outside scrolls.

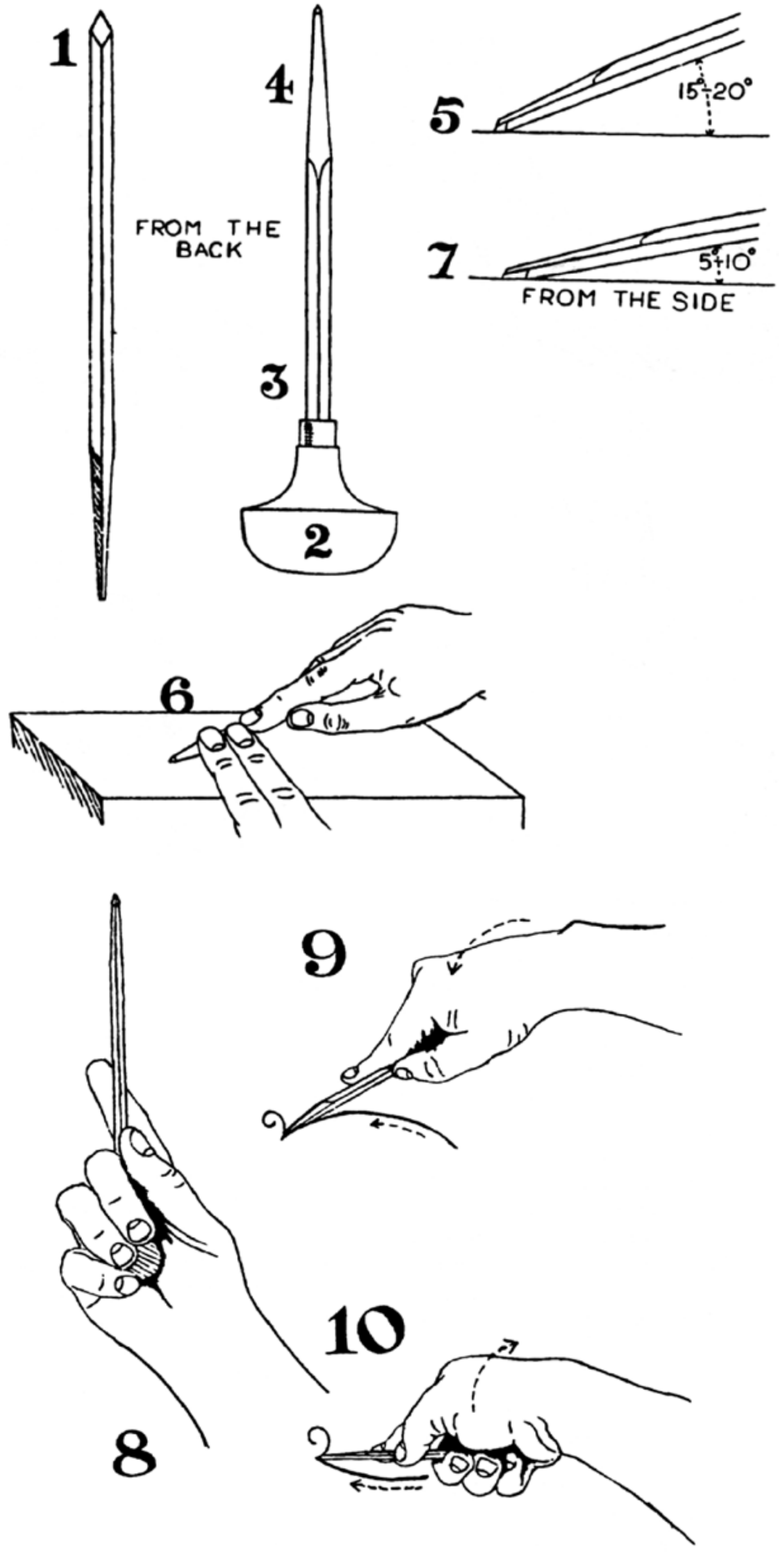

Figure 32: Methods of holding and cutting metal with the square graver.

CUTTING CURVES AND CIRCLES

To begin, get a practice plate of soft steel and scribe a number of circles of different sizes.

Cutting Counterclockwise. Refer to Figure 32 and incline your wrist over to the left, to a greater or lesser degree, depending on the sharpness of the curve. This incline is similar to a motorcyclist leaning the cycle over when rounding a left-hand bend or corner.

Cutting Clockwise. Incline your wrist in the opposite direction from cutting counterclockwise: over to the right. Again, think of the motorcyclist.

Cutting Straight Lines. You will soon realize that it is much harder to cut a straight line than it is a curved or wavy line. In other words, it will take more practice. To begin, use a straight-edge and scriber to scribe some short, straight lines on your practice plates; then use your graver to cut them. Chances are, the lines will not be very straight at first, but keep practicing on these shorter lines. When these start to get relatively straight, make the lines longer and try cutting these. You should eventually arrive at something approaching a straight line.

After you have practiced the curves, circles, and straight lines, and have them looking pretty good, you are now ready to start trying a few advanced designs—namely, scrolls and borders.

ENGRAVING GUN METAL

The first step in engraving a design into hard gun metal is creating the design itself. The simplest, most universally used gun engraving design is the scrollwork pattern.

Basic scrollwork comes straight from the outdoors, where they are seen in patterns of leaves, branches of trees, etc. The serious amateur might go out in the field and practice rendering these patterns into freehand scrollwork drawings.

But if there is not the time for that, there's a shortcut. Scrollwork patterns exist on innumerable firearms. Pictures of these may be found on-line, or in many gun books and magazines, old and new. Get the feel of scrollwork designs by freehand copying some of these. After some practice at copying the identical design, try adding your own touch.

After you get the feel of scrollwork styles, you are ready to try transferring them to hard metal. Select a design that you like, and use it as your base pattern. Be sure it is symmetrical: the right half is the mirror image of the left half.

One way to work with small practice metal plates is to secure one on a block of wood with four brass wood screws. Smooth off the screw edges with a file to avoid cuts. Then you can hold the wood-mounted plate in a conventional bench vise.

It is important that you sit or stand in a position that will not be overly fatiguing. You do not want the work so low that you have to bend over it too much, or so high that your arms are under a continual strain. It's also important to have the correct lighting. The light should be bright enough but it should also be diffused.

With the aid of a 2.5X power magnifying glass, or Optivisor, practice scribing some straight lines into the practice plate. Use the scriber in a way similar to using a pencil. Make the lines short and shallow. Then scribe a series of parallel lines, varying the distance between them. After some straight practice, try scribing short arcs to the left and right, as discussed previously.

After a little practice at scribing the lines, you are now ready to start cutting. With the square graver handle in the palm of your hand, place the cutting tip on one of the scribed lines (the cutting tip will be on one edge of the square-shaped tool to produce a V-shaped groove). With the graver handle held very low, push the graver down the scribed line. At such a low angle, the tool will glide over the line without cutting. Now raise the handle slightly and push it down the line again. When the handle is raised, cutting will begin. It is important that the cuts

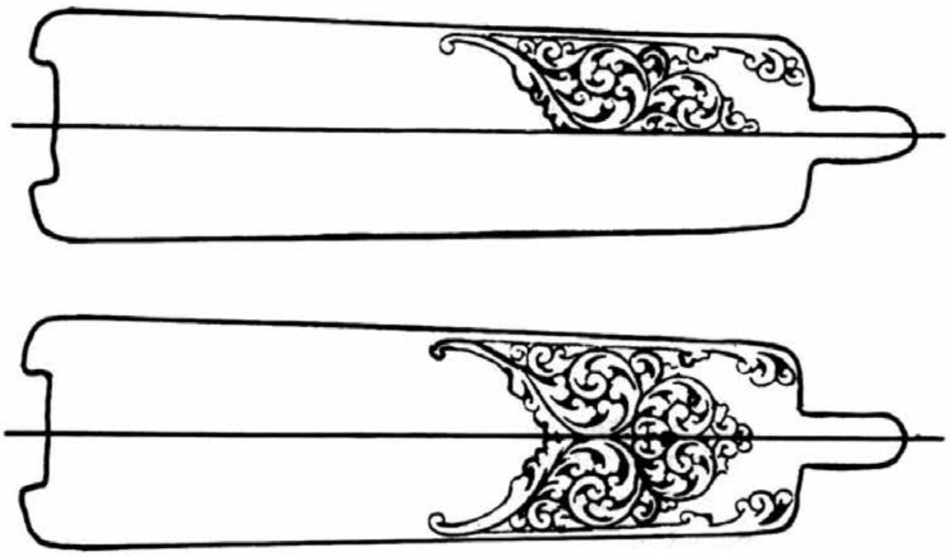

Figure 33: Laying out a symmetrical engraving pattern on a floor plate for a bolt-action rifle.

be kept very shallow — just a hairline scratch at a time. If the handle is raised too high, the cutting tip will dig in and you will lose control, with the added possibility that you will break the graver. Strive for consistency of depth along the line. Use the magnifying glass or Optivisor to check your work as you go. It is important to make the cuts shallow and more often, rather than making them deep and inaccurate.

After some conscientious practice on straight lines, arcs, and scrolls, try scribing a whole element from your base scrollwork pattern. Then, spend some time cutting this element with the square graver.

Once you have gone through six or eight practice plates, you should be ready to try a practice plate the size and shape of the gun part you plan to engrave. It is important that this gun part be relatively flat. A beginner attempting to engrave on a three-dimensional surface is asking for trouble. An additional requirement is that the part you choose to engrave not be made of case-hardened steel or hardened metal alloys. If it is, it will be nearly impossible to cut. Try making a tiny scratch on the surface with a scriber. If you cannot scratch it, you cannot engrave it.

One gun part that is universally used as an engraving surface is the floor plate of a bolt-action rifle. Therefore, a floor plate is used to demonstrate laying out an engraving pattern in Figure 33.

To begin, you should make a template of the floor plate. Remove the floor plate from the rifle and use a wide piece of masking tape around the floor plate. Trim off the excess with a sharp knife. Now peel this trimmed masking tape off the floor plate and lay it on a thin piece of cardboard. By cutting the cardboard to the shape of the masking tape, you have an exact replica of the slightly curved floor plate. Now, by tracing around the cardboard onto drawing paper, you have an area the exact shape of the floor plate.

Once the outline is on the drawing paper, use dividers and a straight-edge to draw a centerline (long way) through the floor plate. Remember, this is going to be a symmetrical design, so it

will be necessary to draw only half the design. Practice incorporating your base design into half the floor plate area.

After you feel the design has become good enough on paper, it is time to practice engraving it onto a practice floor plate. Using your template, draw the outlines of the floor plate on some fresh, clean tracing paper.

Tape your design onto a window or other backlit surface, and trace the half-design onto the tracing paper. By flipping the drawing over, you can trace the other side, giving you a complete design on the paper.

Take the cardboard template and scribe its outline onto a practice plate. Lightly draw in a centerline. Take some Damar Varnish, and with a rag or cotton swab, coat the practice plate.

When you have the basic design perfected, trace the final, clean version onto a fresh template. Then, flip the design over and complete the other symmetrical side. Refer to Figure 33 top and bottom.

You may now scribe the design into the steel. After finishing, you will have the pattern scribed into an outline exactly the size and shape of the floor plate you intend to engrave. Next, after washing the varnish off (kerosene works well), cut the pattern into the steel. When you are finished, you will have a basic two-dimensional scrollwork pattern cut into steel.

Now is the time to go back and study those scrollwork designs you found on guns online or shown in gun books and magazines. Note that the leafy scrollwork patterns aren't merely two dimensional, but rather three dimensional in appearance. By cutting some of the background away at the edges of the leaves with a chisel graver and hammer, the design is made to stand out. Adding shallow lines near the edges of leaves, etc., produces a modeled effect, as shown in Figure 34—the closer together the lines, the greater the curve. A series of cross-hatched lines can give a shadow effect—the deeper the lines, the darker the shadow. Try experimenting with these simple effects on a number of practice plates.

Practice engraving your base pattern into a practice plate. After a dozen or so renditions of your base design, you are probably ready to engrave the real floor plate or other relatively flat gun surface. Just remember to keep the design simple. The professional has many tools and years of experience. But even the inexperienced student can, with a few basic tools and some practice, patience, and time, execute a simple engraving job equally attractive as some professional renditions.

Figure 34: The appearance of roundness can be obtained by cutting parallel lines. The closer and deeper the cuts, the greater the feeling of curvature.

EVALUATING SKILL AND ARTISTRY

"How can I tell a good job of engraving when I see one? I'm a gun collector, not an art collector." Every engraver has been asked a question like this. He or she has also met dozens of self-proclaimed critics. Some of these people have read a couple of articles about engraving by gun writers who may have expert knowledge regarding shooting, hunting or military weapons, but have little or no knowledge of art or engraving. Again, this takes experience; experience in the form of examining and comparing engraved firearms at every opportunity — at museums, in gun collections, in gun magazines and books. By doing so, your eye will become more educated. As a collector or investor, this education will pay off in the form of wise purchases.

Figure 35 shows some early Winchester engravings. Note the relatively simple scrollwork in Figure 35(A). The more elaborate work in Figure 35(B) shows a running deer on this Winchester Model 92 rifle chambered for .44 W.C.F., which was used extensively for deer hunting in the late 1800s. A deer scene, however, would not be appropriate on the Winchester Model 1890.22 rimfire rifle, Figure 35(C). Consequently, a rabbit scene has been engraved — a game animal more suited to the .22 rimfire cartridge. A Belgium-style engraving is shown on the shotgun action in Figure 36. Learn to recognize the different engraving styles on different types of firearms. They will pay dividends in your future as a gunsmith.

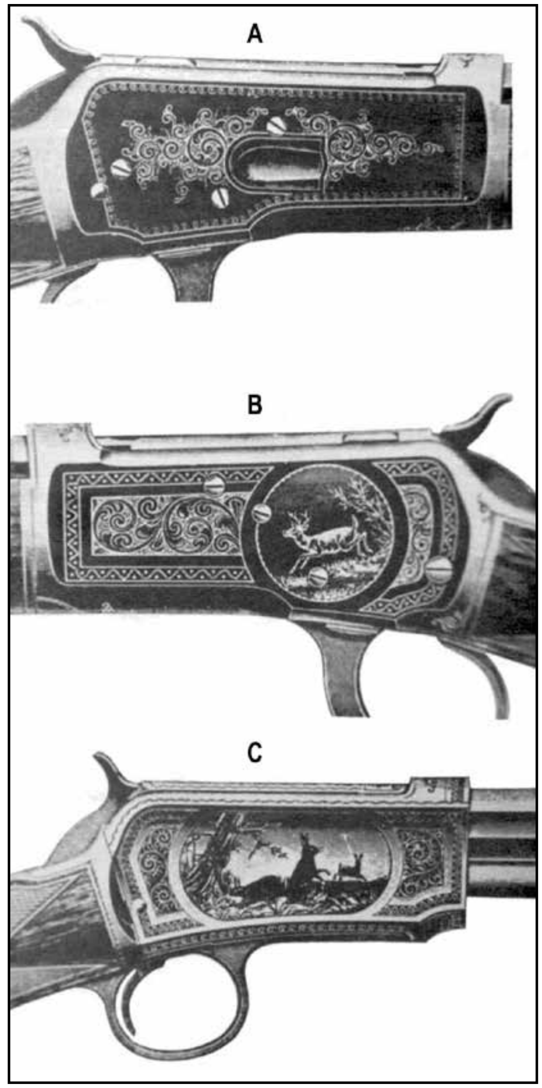

Figure 35: Turn of the century Winchester-style engravings. (A) A Winchester Model 92 lever-action rifle with simple scrollwork; (B) Winchester model 92 with a running deer scene; (C) Winchester Model 1890 rimfire rifle with a rabbit scene.

Figure 36: A sample of a Belgium-style engraving.

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Principles of Etching Metal

Metal surfaces, like the pistol in Figure 37, may be etched with an etching solution usually consisting of nitric acid, but first the metal surface is covered with an acid-resistant coating called a *ground*. This coating can consist of wax, pitch, or asphaltum. The desired design is then scratched through this coating and the metal underneath may then be treated with the etching solution. To obtain the design, you can use the GRS patterns as discussed previously or design your own, or you can even use a combination of etching and engraving.

Coat the metal surface with the ground, transfer the pattern to the ground, then scratch through the ground — following the lines of the pattern — to the metal surface below the pattern. Then, you are ready to apply the etching solution. But let us stop right here and say that nitric acid is highly corrosive and should be handled with great care. Wear rubber gloves, a face shield, and wear protective clothing when mixing it and always slowly add the acid to the water; never add

Figure 38: Etched metal.

water to acid! **If you should spill any on your skin, flush the area immediately with cold water and if burns are severe, get medical attention immediately.**

Do not try this method on anything of value until you have had plenty of practice on scrap pieces of metal, and then only if you have assured yourself that you are capable of doing the job. In fact, this is good advice for any phase of gunsmithing, not only etching. When etching metal, it is best to seek professional advice and let the professional supervise while you practice a few times.

Figure 37: Beautiful example of etching on a Scottish MacLeod marked all steel flintlock pistol.

The professional gun engraver normally uses a lacquer that he or she mixes to cover the metal. White beeswax is melted in a clean receptacle to which the same amount of mastic is added. The two ingredients are mixed thoroughly before adding an amount of pulverized Syrian asphaltum equal to the two parts already in the container. All of these ingredients are melted together evenly by stirring them while they are being heated. When they are thoroughly mixed, the mixed ingredients are poured into a pan of water, and while still warm, they are pressed into small bars with the fingers. When ready to cover the metal to be etched, a small amount of this substance is scraped off the bar into a shallow container and enough turpentine is added to dissolve it.

The design is scribed on the gun metal and is then covered with the lacquer using an old ink pen as an applicator. The lacquer should be just thin enough to flow readily through the pen. When this is dry, the remaining surfaces on the gun part are covered with wax, pitch, asphaltum, or a combination of these. Most gun engravers use a mixture of wax and asphaltum that is heated until mixed and slightly warm so that it can be painted on the gun surface with a small brush. When completely covered, the part is dipped in acid for a given length of time so that the metal surface not covered with the asphaltum mixture will be eaten away to a certain degree and leave the design. It is then cleaned.

For the covering, ready-made asphaltum varnish may prove the best to use while scribing the metal parts, because when allowed to dry hard, it will cut well and leave clear, sharp lines. After etching, the varnish may be removed with turpentine.

Solutions for etching metal should always be mixed and applied in glass containers or containers heavily coated with asphaltum. For fast etching, nitric acid is usually used full strength. For slower action, the acid may be diluted by carefully adding 1 part water. When the process is done with a diluted solution, it should be stirred occasionally to remove bubbles and scale that may interfere with even biting. Store the solution in glass bottles with acid-proof caps.

Aluminum trigger guards, for example, can be etched in the same way as steel except muriatic (hydrochloric) acid is used instead of nitric. Full-strength muriatic acid will etch to a depth of about 0.003 in. per minute. The etching is slower, but can be kept under control much better by diluting 1 part acid to 3 parts water.

JEWELING

Jeweling is one gunsmithing technique that is normally used on bolts of bolt-action rifles. However, the practice is also useful on other gun parts such as hammers, internal action parts, etc. Jeweling metal, often called engine turning or Damascening, involves overlapping spot-polish marks on metal that give a hammered effect. To perform this operation, you will need an engine turning chuck. This tool consists of a steel holder with a 1/8 in. shank and an abrasive charged rubber tip. The specially made abrasive tip gives an even impression on steel and simplifies the work of engine turning and eliminates the danger of cutting deep rings.

Many shops use engine turning brushes rather than the tips. Those brush wires follow the contours of the rounded gun parts better, giving a complete jeweled pattern. They are also reported to be superior on flat surfaces with long tool

Figure 39: Jeweling bolt attaches to a drill.

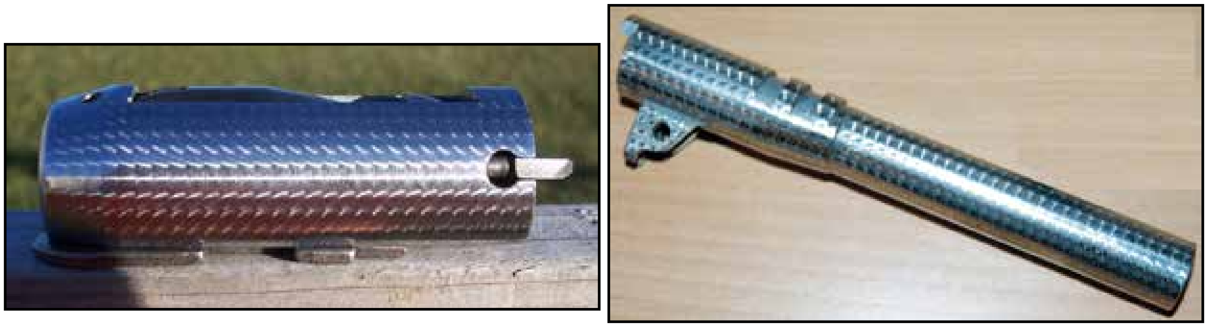


Figure 40: Examples of jeweling on a bolt.

life. Silicon carbide abrasive and oil are used in conjunction with the wire brush to obtain the pattern. The drill press RPM should be fairly high: above 2000.

The bolt (Figure 39) is secured between an arbor inserted into the rear of the bolt and a centering pin in the firing pin hole. The fixture containing the bolt is placed on a drill press table against a straight-edge fence and clamped to the table. The bolt body should be centered under the engine-turning tool that is held in the drill chuck. Coat the bolt with abrasive compound and start the pattern. Start at either end of the bolt, but once started, continue from this same end for all rows. Bring the engine-turning tip or brush down on the bolt and make the first spot. Then move the fixture along the straight-edge fence approximately one-half the diameter of the spot and bring the brush down again on the bolt to overlap the first spot.

Continue this procedure until one row of spots is completed. Then the bolt is rotated approximately ½ of the diameter of a spot and the process is repeated for another row. This continues until the entire bolt has been fully jeweled in the areas desired (Figure 40).

NOTES

Chapter 2: Bluing and Browning Gun Metal

Introduction

Firearm refinishing is one of the most rewarding phases of gunsmithing work. Besides its monetary rewards, gun bluing also helps the gunsmith learn about various types of guns. As the guns are being disassembled for polishing and bluing, the operating characteristics of each gun become familiar. After repeated handling of the more popular guns, the gunsmith knows almost immediately just what parts are worn, broken, or need replacing.

Few gunsmithing operations are as gratifying as seeing a rusted and badly abused firearm turn into a beautiful, rich, blue-black finished firearm. For those unfamiliar with the firearm

bluing operation, the process is like magic. It turns a worn firearm into one that looks brand new. But the person doing the work knows that the process is not an act of magic. Rather, it is accomplished by a masterful job of brightly polishing all the surfaces, keeping the corners sharp, and not funneling the screw holes. The gunsmith also makes certain that all parts are thoroughly cleaned with a degreasing solution before bluing. The results are rewarding — a perfect blue-black finish on the steel that will last for years.

CHEMICAL USE SAFETY

All chemicals carry varying degrees of hazardous exposure. It is essential that you undertake basic safety precautions when dealing with dangerous compounds.

- First and foremost, know what you are dealing with! There are different types of chemicals that come in various forms: liquid, gas, vapor, dust, fume, or mist. Before handling any chemical, understand its properties, how it is used, and how it must be handled to avoid harmful exposure.

- Know what to do in case of emergency! Using safe practices when cleaning up leaks or spills and knowing when to call emergency help will minimize harmful effects.

ZERO IN

- Always wear protective gear when dealing with any chemical. A rubber shop apron, gloves, and boots, as well as a face shield and hat should be worn at all times.

- Mix all chemicals in well-ventilated areas, preferably outdoors.

- In case of contamination, wash all skin thoroughly, and , if necessary, dispose of clothing. If clothing can be safely laundered, wash separately after rinsing items outdoors using a hose or washtub.

- Never bring food into an area where chemicals are being used or stored. Wash hands, or shower and change clothes before eating.

- Keep the work area free from contamination by properly cleaning up spills immediately, and appropriately disposing of hazardous material.

- Know the proper way to store or dispose of any leftover chemicals.

- Make sure at least one other person is available to undertake emergency measures should you become incapacitated from harmful exposure.

Basic Bluing

The earliest bluing solutions consisted of a mixture of nitric acid and hydrochloric acid with steel shavings or iron nails dissolved in them. The process used in applying solution to the gun metal is generally known as the slow rust bluing process.

In general, the slow rust process consists of polishing the metal parts to be blued to the desired luster and then degreasing the parts by boiling them in a solution of lime and water or lye and water. Without touching the metal parts with bare hands or otherwise letting them become contaminated, the metal is swabbed with the bluing solution in long, even strokes until all parts are covered. The metal is then allowed to stand and rust from 6 to 24 hours. Afterward, the rust is rubbed off with steel wool or a wire brush to reveal a light gray or bluish color underneath.

The surface, still free from oil, is again swabbed with the solution and allowed to rust another day. When this second coat of rust is removed, the metal beneath is an even darker shade of blue. The process is repeated until the desired color is obtained, taking anywhere from one to two weeks on the average, depending upon the metal and the humidity in the air. The parts then are boiled in water for about 15 minutes to stop further rusting action, and finally oiled. The result is a beautiful, long-wearing metal finish.

The time required to obtain a perfect finish by the slow rust bluing process forced gunsmiths and manufacturers to seek a faster and easier process. The one developed has been called many names such as 20-minute bluing and express bluing, but hot water bluing is generally the accepted term.

Hot water bluing is based on the fact that steel rusts more rapidly when hot than when cold. This is due to a more rapid absorption of the oxygen that forms ferric oxide, or red rust. Therefore, new formulas were developed that reacted favorably on metal that was polished, degreased, and then heated in boiling water.

Other bluing methods were developed—niter bluing, charcoal bluing—but the major development in gun bluing occurred around the turn of the century when the black oxide, or hot caustic bluing process was patented. This method requires that the parts be polished in the conventional way, but instead of applying the solution to the metal parts, the parts are dunked into a tank of the boiling solution. Once in the tank, the bluing process is essentially a 15-30 minute process of boiling the parts in the strong

Figure 1: Some of the cold bluing solutions on the market.

alkaline solution. The process works exceptionally well on a wide variety of steel and is much more economical for mass production than any other process. Another advantage of this method is that the number of guns that can be blued at one time is limited only by the size of the tank and the heating facility.

During the early part of the twentieth century, an instant or cold bluing process became popular with do-it-yourselfers. The trend is still popular today. The cold bluing solution is a mixture of acids and copper nitrate. The copper nitrate forms a plating on the metal and the acids turn the copper black the instant it touches bare, degreased metal.

There are many kits on the market that contain everything necessary to blue guns at home. If care is taken, the result can be quite pleasing. The main problem is durability. None of these cold bluing solutions will hold up for any length of time, and eventually the gun will be coated again with red rust.

However, these cold bluing solutions do have a place in every gun shop — for touch-up jobs. The cold bluing solutions on the market will most definitely blacken metal, if the metal is properly prepared. Of these solutions, Birchwood-Casey's Perma-Blue Paste, or G96 Gun Blue Creme are good choices for a first attempt at touch-up gun bluing.

COLD BLUING TECHNIQUES

Cold bluing chemicals will not blue case-hardened steel, stainless steel, aluminum, or other nonferrous metals. Case-hardened steel can be readily detected by the mottled colors running through the surface of the steel. If these colors have faded, the metal will usually have a chrome appearance. Stainless steel barrels are usually marked as such. Aluminum or other nonferrous metals will not react when touched with a magnet.

The chemicals used in cold bluing solutions are poisonous and should be treated accordingly. Many of the chemicals will affect bare skin, so it is recommended that rubber gloves be worn when using them. Skin-tight surgical gloves, available from drug stores or medical suppliers, are ideal for cold bluing. They allow free movement and feel, yet give adequate protection from harmful chemicals.

There are dozens of cold bluing solutions available on the market, some of which are shown in Figure 1. Because many of them vary in strength and application technique, the manufacturers' instructions should always be followed. In general, no heat is required to apply the bluing solution, but the metal surfaces must be oil-free for best results. After cleaning the surface to be blued with a solvent, the bluing solution is applied in even strokes over the surface with cotton swabs, left on for a few minutes, and then wiped off. Successive coats are applied until the desired finish is reached. Then the area is thoroughly swabbed with gun oil.

As mentioned previously, the cold or instant bluing method is recommended only for touch-up jobs. In a pinch, it will produce a nice-looking, complete blue job if correct procedures are followed: proper polishing, removing all pits and scratches from metal, degreasing, and applying the solution evenly. When completed and oiled, the final result will appear quite similar to a factory hot caustic bluing job, especially immediately after the job is finished and the metal surfaces are oiled. However, this appearance does not last as long as some of the other methods.

HEAT BLUING TECHNIQUES

Heat bluing is used extensively in the gun shop, mainly to blue small parts such as screws, drift pins, etc. This method is especially useful when replacing one screw or pin that would not warrant "firing up" the hot caustic bluing tanks. The

Figure 2: If you are called upon to restore older firearms to their original condition, like this early Winchester Musket, you must know how to niter blue to obtain an authentic finish.

oil-and-heat method is one of the favorites for bluing such parts, and the procedure is simple.

Polish and degrease the parts to be blued in the usual manner. Use a piece of stovepipe wire or a pair of long-nose pliers to grip the part to be blued and heat the part with a propane or similar torch until it is a dull red color. Then, quickly plunge the part into a small container of oil or transmission fluid. It should turn a nice temper-blue color. If you want the color darker, repeat the operation. Be careful of the oil igniting, and do not touch the heated part while still hot.

Heat, or temper, blue was used extensively on some parts of the earlier firearms manufactured by Winchester, Marlin, and others. To obtain this temper blue, such methods as torch heat, charcoal, sand, and niter were used as the heat-transfer media. The excellent finish found on Winchester firearms, however, was the result of good steel and perfect polishing, rather than the bluing process (Figure 2).

Niter Bluing. The niter process of bluing steel is a quick and easy method for bluing small parts such as screws, triggers, hammers, etc. Of course, it can also be used for receivers and other large parts, but the expense of setting up for the larger parts will far outweigh the cost to purchase equipment for the hot caustic bluing method.

In using this method, there are several precautions that should be followed to prevent bad burns and/or damage to eyes.

Always wear a face shield or safety goggles, heavy clothing, and gloves to protect the skin.

The main reason for this protection is if any oil or water (just one drop) should fall into the hot niter mixture, 700° molten lava will spray out, causing severe burns!

The next precaution is to make absolutely certain that the parts to be blued are free of water and other liquid before placing them into the solution.

To begin, you need a cast iron container large enough to hold the parts so they will be completely covered by the bluing solution. A lead melting pot, like the one shown in Figure 3, is okay, as long as it is completely clean. A small gas or electric hot plate will serve for the necessary heat. You will then need enough potassium nitrate, commonly called saltpeter, to fill the melting container.

Figure 3: A lead melting pot will suffice to hold the niter bluing solution when bluing only small parts like screws and triggers.

The parts to be blued are polished and cleaned to remove all traces of grease. Be sure that the parts are completely dry before immersing them in the bluing solution; especially check blind screw holes for possible trapped liquid.

Set the melting pot onto the source of heat, and sprinkle a little of the potassium nitrate in the pot. When it has melted, at about 700°, sprinkle more in. Continue this until you have enough melted potassium nitrate, or niter bluing solution. Attach a black iron wire to each small part to be blued, and once you are certain that no liquid is present on the part, gradually lower it into the melted bluing solution.

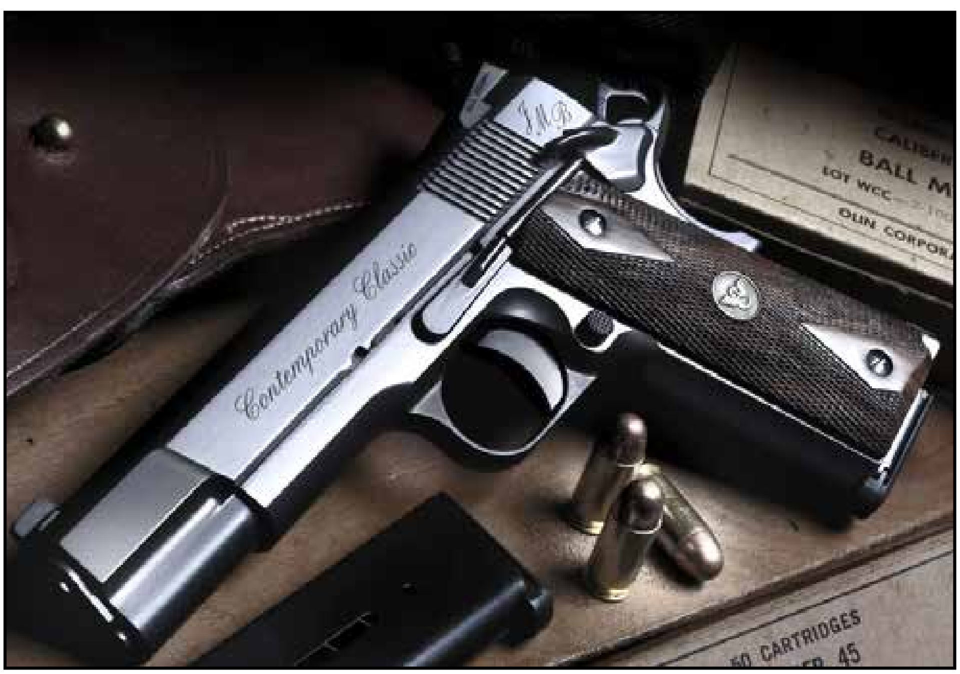
Let the part remain in the molten solution until a uniform color of the desired shade is obtained. This usually takes from 10 to 30 minutes, depending upon the size of the part. The part is then removed from the solution and immediately plunged into warm water. In a few seconds the part will cool; then wipe the part off and oil it thoroughly.

If you have done your part on the polishing and degreasing, you should have an attractive, rich, blue-black finish.

Charcoal Bluing. Charcoal bluing, used to color some metal parts on early firearms, is another form of temper or heat bluing. The finished color ranges from a light blue to a dark blue-black, depending upon the temperature of the charcoal. This bluing method was used mainly on small parts such as screws and pins that did not lend themselves to easy rust bluing.

Your first attempt at charcoal bluing can be done with a small cast iron melting pot over a gas camp stove. A few bricks of commercial charcoal are placed in a cloth bag and pulverized with a mallet until small granules about the size of peas remain. These are then dumped into the melting pot to be heated. You do not want to get these coals red-hot, just hot enough so that an even temperature of about 600°-700° F is held.

The parts to be blued are polished as usual and degreased. Attach black iron stovepipe wire around each part so that it can be removed from the charcoal without being touched. If the temperature is correct, the parts should be ready about 10 minutes after being placed in the heated granulated charcoal.



Beautiful example of charcoal bluing.

Pour a can of car transmission fluid into a separate container large enough so that the fluid will completely cover the objects being blued. Using the wire so as not to burn yourself, lift one of the parts from the charcoal and inspect it. If it has taken on the proper blue-black color, then quickly immerse it into the container with the transmission fluid. Wait until it cools and then remove it and place it aside.

Repeat this procedure with all the parts. If the initial inspection shows an improper color, place the part back into the charcoal. However, once the part has been dipped into the transmission fluid it will have to be degreased before returning it to the charcoal.

The process is completed by wiping off the parts with a clean rag and then oiling them. If care is used in the polishing, degreasing, and preparation of the charcoal mixture, you should have a nice, authentic-looking satin blue-black finish when completed.

Clyde Baker, in his comprehensive book, *Modern Gunsmithing*, gives a slightly different method. He recommends making a container of heavy sheet iron large enough to hold the largest part to be blued. Since no liquid will be used in the container, it is not necessary to have tight seams; merely fold the corners. Fill the container with pulverized wood charcoal in lumps about the size of a small pea, and heat the container until the charcoal is partly burning throughout, but not red-hot. Attach a rod or wire to the part to be blued and bury it in the glowing mass, allowing the rod or wire to stick out to be used as a handle. In 5 or 10 minutes, lift the part out and examine it. If it is the right color, take a large, clean cotton rag, ball it up, dip it into some powdered lime, and rub the part vigorously all over.

Put the part back into the glowing charcoal as soon as possible. Repeat this treatment every 7-10 minutes, using plenty of lime and rubbing it into every part, working very quickly. Be extremely cautious so as not to burn yourself. Continue this treatment until a rich blue-black color has appeared, then let it air-cool before applying a light gun oil to the part. The parts have to be polished and cleaned as any type of bluing.

Either one of these methods will work fine on small gun parts. If you have complete control of the temperature, an entire gun may be blued this way, but getting an even color throughout is not an easy task without the proper equipment. Therefore, we recommend this method only for screws, triggers, pins, and other small parts.

Detailed information on hot caustic and other bluing methods, including the equipment needed, is covered later in this lesson.

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Hot Water Bluing

Hot water bluing formulas were closely guarded by professional gunsmiths of the day. It seemed that gunsmiths had each developed their own formula. Even different manufacturing plants had their own "secret" method of getting the desired results. However, most of the formulas were based on a solution consisting of sodium and potassium nitrates, potassium chlorate, and bichloride of mercury, mixed in distilled water. One well-known formula is as follows:

- ¼ oz. potassium nitrate
- ¼ oz. sodium nitrate
- ½ oz. bichloride mercury
- ½ oz. potassium chlorate

Mix the above ingredients in a clean, wide-mouthed glass jar. Then, slowly add 10 oz. of slightly heated (120° F) distilled water into the container holding the mixed dry chemicals. Stir with a glass rod continually until almost cool, and then pour the contents into a dark brown glass or plastic bottle with a tight plastic cap. Keep the mixture in a dark, cool place.

Chemicals are expensive these days when purchased in small quantities, and you will save money by purchasing one of the commercial bluing solutions. Brownells sells Belgian Blue or you can search for gun shops in your area that may sell this hot water bluing solution at www.gunshopfinder.com. This solution is excellent and you should experience very few problems, provided you follow the instructions exactly.

POLISHING EQUIPMENT

To prepare the metal for hot bluing, remove all pits and polish the metal to the desired sheen. You will need a 10 in. mill bastard file and file card if the gun has rust pits, nicks, or scratches too deep for abrasive paper to remove.

Purchase at least three sheets each of the following grits of open-coat aluminum oxide abrasive paper.

80-grit	240-grit
150-grit	320-grit
400-grit	500-grit

The 400- and 500-grit silicon wet/dry paper is used for the final polishing.

Figure 4: Brownells makes a complete tank set for bluing.

Figure 5: Besides bluing tanks and a heat source, some of the items shown here are also required to obtain a professional bluing job using the hot water method.

If your local hardware or automotive supply store does not have them, you can order online.

BLUING EQUIPMENT

If you have a bench vise and two watertight metal containers large enough to hold the parts to be blued, you already have much of the material needed. However, if not, get two 6 in. x 6 in. x 40 in. bluing tanks. One will do, but two are better, and the kit shown in Figure 4 contains most of what you'll need. Make sure the tanks are made of metal or stainless steel, but ***never*** *galvanized metal*.

A package of steel wool and a stainless steel brush made of .005 in. hand-tied stainless steel wire are necessary for removing the rust from the gun. Clean rubber gloves are recommended during the bluing operation to insure that your skin will not come into contact with the metal. All of these materials are shown in Figure 5.

Several good degreasing solutions are available, but a can of household lye (sodium hydroxide) will do the job adequately. If you use a commercial cleaner, always follow the directions on the package.

A source of heat can be the kitchen range, but you will do better to work in the basement or garage and use a camp stove or gas-fired hot plate for your heat source.

Chemicals added to city water supplies will sometimes have an adverse effect on the final bluing job. Some "hard" well water can do the same thing. Therefore, either buy distilled water or try catching 8-10 gallons of rainwater in plastic dishpans.

You will need some tapered dowels to plug the bore of the barrel and some black stovepipe wire to attach to each part during boiling. The dowels may be made of wood, plastic, or similar material. Finally, you will need a pack of cotton balls and a wooden clothespin or two for holding the cotton.

Do not be discouraged by the hard work. Remember that the result is a bluing job that is superior to many factory finishes.

PROCEDURE FOR HOT WATER BLUING

Regardless of whether you use the Belgian Blue or mix your own formula, the procedure for hot water bluing is the same.

Polishing. Aside from keeping the metal surfaces free of oil, polishing is the most important step in getting a rich, velvety finish on your gun parts. Without proper polishing, you might as well forget bluing the gun and leave it as is. The coloring of the metal will never cover up pits, scratches, etc. The surface of the metal must be perfect before the bluing solution is applied.

Many professional shops use power tools for buffing or polishing the metal parts. However, it takes lots of experience and practice to do a good job of power polishing without rounding sharp corners, funneling screw holes, or otherwise "grinding them up" too much.

The beginner should stick to hand-polishing. Hand-polishing will insure that all contours, lettering, markings, and square edges are properly preserved. About 12 hours of hand-polishing are required to complete all parts on the average rifle or shotgun. If many pits are present, this time may be doubled.

The first step is to disassemble the gun down to the last screw and drift pin. If you are unfamiliar with the takedown procedure, exploded views and instructions are available from various sources for most firearms. If you have no printed instructions, jot down notes as you disassemble the gun and perhaps even take close-up photos of intricate parts. Then you will have some reference to follow when you are reassembling the firearm.

Wipe the parts clean, examine each for wear, and be sure that no aluminum alloy parts are present. This can easily be determined by using a small magnet. If the magnet does not react, then the part is nonferrous — aluminum, brass, or a similar alloy — and these parts should be set aside with others not to be blued. Besides the nonferrous parts, other parts will include springs and other small elements not visible in an assembled gun.

With all the pieces to be blued in one pile, thoroughly clean each one with a solvent such as acetone. Then start polishing the parts as discussed earlier in this course.

Once all the parts are polished, you are ready to start heating your tanks. However, if there is going to be any delay between the polishing and bluing, certain precautions must be taken. A freshly polished gun is a prime target for surface rust if it is not going into the cleaning tank immediately. A delay of a few days, or even a few hours under some conditions, between final polishing and bluing can result in fine "silver" spots showing up on the gun after being blued. These are the result of microscopic rust spots developing while the gun is being held after polishing and prior to bluing.

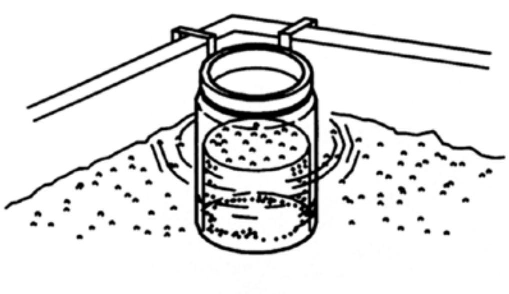

Figure 6: A clean jar containing the bluing solution should be suspended in one corner of the tank by a black iron wire. Be careful not to splash any of the tank water into the jar.

Cleaning. Once the parts have been polished, pour enough clear water into one of the tanks to completely cover the gun and all its parts. Add the right amount of cleaning solution — Dicro-Clean No. 909 or 1 tablespoon of household lye to 2½ gallons of distilled water or rainwater. Then suspend the gun and gun parts by black iron stovepipe wires. Make sure that all parts are at least 1 in. away from the bottom of the tank and also away from the tank sides, otherwise, blotchy bluing will result. Small parts can be individually suspended by black iron wires or else placed in a black iron or stainless steel basket, which is then suspended in the tank. Let the parts soak in the cleaning solution for about 5 minutes.

Boiling the Parts. While the parts are being cleaned in the alkali cleaner, clean rain or distilled water is being heated in another tank. A clean glass jar containing the bluing solution is suspended in one corner of the tank, as shown in Figure 6, so that part of the jar is underwater (heating the bluing solution). Be careful not to let any water in the bluing tank splash into the jar; this will weaken and contaminate the bluing solution.

After the cleaning period is completed, remove the parts from the cleaning tank and quickly transfer them to the rinse tank. The rinse tank contains clean rain or distilled water that is not heated. After rinsing, the part is immediately

put into the hot water tank (the one containing the jar of bluing solution).

The water in the hot water tank must be kept at a hard, rolling boil from here on out, if the best results are to be obtained.

Let the parts boil for a full 15 minutes the first time to insure an even heat throughout and then lift the largest of the parts out of the boiling water. The part should dry in a split second if it has been heated enough. If not, put it back into the boiling water and boil it a little longer. Do not worry about getting the parts too hot; the only danger is not having them hot enough.

Applying Solution. When the part dries, suspend it in mid-air by the wire; or, in the case of the barrel, which should have wooden or plastic dowels in each end as holding plugs, rest one wood plug on a table and hold the opposite plug in your gloved hand. Then, as quickly as possible, dip a swab into the hot bluing solution in the suspended jar and dampen the swab. Do not saturate the swab, just dampen it. Apply the solution in long, even strokes. The parts should be hot enough so that when the solution is applied it dries immediately and leaves a light grayish-brown coat on the part.

After each part has been coated, return it to the boiling water for about 5 minutes. Then, remove the part again and swab more of the solution onto the hot metal surfaces. Do this to each of the parts in turn.

Carding. Following the second application, you will see a darker coat of gray, flecked with rust, forming on the metal. Before returning the part to the hot water tank, rub the parts with clean steel wool or use a motor-driven wire wheel, as shown in Figure 7, to remove the rust particles. For tight places, uses a clean stainless steel brush. This process is called carding. Do not rub the parts too vigorously because that could remove the thin coat of light grayish-brown blue.

Figure 7: To card off the light coat of rust that forms after bluing, use steel wool, a stainless steel brush, or a motor-driven wire wheel. Be sure to remove only the loose rust and not the thin coats of color underneath.

After all parts have been carded, return them to the hot water tank for another 5 or 6 minutes, and repeat the previous steps. As you put on more coats of the bluing solution, the brown or grayish-brown gradually turns to a rich, velvety blue-black color. This might require as few as 4 coats on a .22 rimfire barrel, or as many as 10 or 12 coats on harder steel. According to Clyde Baker, stainless steel requires 30 or more coats of bluing solution.

Final Boiling. After the last coat has dried on the parts and has been removed with steel wool, wire wheel, or stainless steel brush, place the parts in the boiling water once more and boil them for about 20 minutes to stop all further rusting. The parts will dry almost immediately

upon being lifted from the water. When cool, oil all the parts. Other than assembling the various parts, the job is now finished.

NOTE: On some metals, especially those blued for the first time, an etching solution might be needed to open the pores and permit the color to "take" properly. In most cases, a solution of one part nitric acid to seven parts distilled water works fine — even on hard steels. When bluing stainless steel barrels, instead of the etching solution, you can mix your own acid. First, mix ½ oz. silver nitrate with 13½ oz. of distilled water. **NEVER POUR WATER INTO ACID; IT WILL ERUPT VIOLENTLY!** Then, add ½ oz. mercurous nitrate, and finally, 5½ oz. of nitric acid. Put the solution into a brown bottle and do not expose it to light any more than is necessary.

Etching. To etch the metal surfaces, heat the gun and gun parts in the boiling water prior to applying the bluing solution. When hot, lift them out and quickly coat each part with the etching solution, using a clean sponge or rag. Work very quickly. Splash on plenty of the etching solution and try to cover the entire surface in one or two strokes. Keep going over all the parts to keep them wet. In a very short time, usually only a few seconds, the surfaces will take on a slightly frosted, silvery appearance. Inspect each part carefully. If any areas seem to be uneven, coat these again and hold a few seconds. Otherwise, plunge the parts instantly back into the boiling water and continue the bluing procedure as discussed previously.

Bluing Small Parts. Small gun parts such as screws and drift pins are sometimes more difficult to blue than the rest of the gun because they lose their heat quicker when lifted from the hot water bath. One way to overcome this is to have your swab damp with the bluing solution before lifting a part out of the water. Then, immediately after it surfaces, coat the part with the solution. Try to coat the part when it is no more than 1 in. out of the water.

Figure 8: If the gunsmith is called upon to restore antique firearms, a good knowledge of slow rust bluing is essential.

SAFETY PRECAUTIONS!

Like most firearm coloring methods, the chemicals used for hot water bluing can be dangerous. Most formulas can be fatal if swallowed and many cause severe burns. Therefore, be extremely careful when working with any of these chemicals. Wear rubber gloves and safety glasses, and avoid inhaling any of the fumes.

If any of the chemicals come into contact with the eyes, flush with water for at least 15 minutes and get medical attention immediately thereafter. If chemicals are swallowed, give water or milk and egg whites if available. Repeat if vomiting occurs and get medical attention immediately.

Keep these chemicals in a safe place away from children or pets or where they may be mistaken for something else. If you mix your own solution, be sure to label the container POISON and keep it in a safe place.

TROUBLESHOOTING HOT WATER BLUING

Hot water bluing solutions depend upon heat for their action. Therefore, the solution and metal must be kept hot during the entire operation. Work as fast as possible in applying the solution, so that the temperature will not drop rapidly. When the bluing solution is applied, it should dry almost instantly. If it does not, either the solution or the steel is not hot enough. The obvious correction is to raise the temperature of both, but once water boils, that is the highest temperature it can reach. So leave the metal parts in the boiling water longer if they appear not to be hot enough.

If there are small parts that do not "take" the bluing solution readily, you should hold them for an instant over an open flame before applying the bluing solution. You can dip small pins and screws into the hot solution rather than trying to swab it on. Very thin parts such as magazines will not hold the heat long enough as they are, so it is a good idea to fill them with metal blocks, rods, or other clean metal objects to help hold the heat longer.

Steel varies in different guns, and in some cases the bluing solution will be too strong for the gun metal. In this case, when the solution is applied, a heavy brown rust will appear. To correct this condition, weaken the solution with a few drops of distilled water. If the solution is too weak, discard the solution and add fresh solution to the clean jar suspended in the boiling water.

One of the worst problems with hot water and slow rust bluing is the bleed-out of water onto the surface of the metal. Blind screw holes, dovetail notches, and other parts will retain water when the parts are lifted from the boiling tank. This water will eventually dissipate onto the metal surfaces and thin the bluing. Compressed air is the best remedy for this situation. Merely give the trouble spots a shot or two of compressed air to force the trapped water out.

Remember, a good hot water bluing job can be obtained only if everything is just right. The main secret of successful hot water bluing is cleanliness and heat. Therefore, special attention should be given to both.

Slow Rust Bluing

Most experts agree that slow rust bluing produces the most durable blue-black finish obtainable on gun metal. In fact, many manufacturers used this method of finishing on all their guns prior to World War II (Figure 8). Then, as mentioned previously, the hot caustic bluing method became the most logical for mass production. The main problem with slow rust bluing was the time element. It takes from 3 to 10 days to obtain a good slow rust finish on firearms. This time element is too long and, consequently, too expensive for most of today's gunsmiths and customers. However, there are some custom-built rifles that still boast the coveted slow rust finish, as shown in Figure 9. Here's how to obtain it.

Use the same preliminary procedures as discussed for hot water bluing; that is, metal preparation, cleaning, etc. Then fill each of two bluing tanks with enough water to cover all parts completely. In one tank, add a cleaning solution according to the instructions on the package; conventional household lye in the proportion of two tablespoons of lye to each gallon of water will work well. Bring the solution to a boil and then put all the parts in the tank and suspend them so that none touches the bottom of the tank. Leave the parts in the boiling solution for about 5 minutes; too long a time will cause premature rusting. Then, immediately transfer the parts into the tank containing the clean boiling water.

Let the parts remain in the clear water for 2 minutes, remove them, then hang them up to dry and cool. At this point, your hands must never touch any portion of the metal that is to be blued. Also make sure that the clean boiling water is kept at a hard rolling boil. When the parts are dry and cool, take a clean cotton swab, saturate it with a slow rust bluing solution, and rub over the parts with smooth, even strokes.

In recent times, there have been so many different slow rust bluing solutions that it is difficult to recommend any one brand. Stoeger's Gunsmith Bluer was a favorite for years before it was discontinued. Then it was once again placed on the market in the early 1980s, only to be discontinued again in 1987. You might try Brownells and Dixie Gun Works for the names of the ones currently available. The one that most gunsmiths use is Pilkington Classic American Rust Blue, which is available from Brownells.

Regardless of the solution used, the process is generally the same. Apply some solution to the swab and squeeze out any excess. With long, even strokes and moderate pressure, swab all areas to be blued. Do not use an excessive amount of solution. The rust bluing solution will also act as a rust remover if too much is applied. After all areas have been covered, hang the parts to

Figure 9: Slow rust bluing gives the gun metal a durable satin finish — a finish that is currently unobtainable from most factories.

rust in a damp, humid place for about 6 hours. In some areas, the air is too dry for the gun to rust properly. Therefore, a steam cabinet must be made to help this rusting process along. The cabinet can be kept simple. The one shown in Figure 10 is made from ¾ in. plywood with a hinged door. A lamp holder and a 100-watt incandescent lamp are used to heat an enameled pan filled with water. The gun parts are then hung from hooks in the cabinet above the steam to accept the heat and steam. About 1½ hours is all the time necessary to get the parts rusting properly when the steam cabinet is used. Take the parts out of the cabinet after this amount of time, and let them continue to rust for a few more hours outside the cabinet. Applying more bluing solution too soon will cause pitting, so wait at least 3 hours between coats.

Fill one of the tanks with clean water and again bring it to a rolling boil. After all parts coated with the bluing solution have rusted the required length of time, return them to this tank for about 20 minutes. After boiling the parts, hang them up to dry and cool. All accumulated water droplets in corners, screw holes, etc., should be blown away with compressed air. When the parts have cooled, remove all rust with a clean steel wool or a powered wire buffing wheel. For tight places, use a clean stainless steel brush. This first carding may give you any color from a light gray to a light blue; it may be splotched, or uniform. Do not let this bother you. Each succeeding pass will deepen the color and make it more uniform. When all parts are thoroughly carded with steel wool or brush, repeat the application with the bluing solution: boiling, applying the solution, rusting, boiling, and carding.

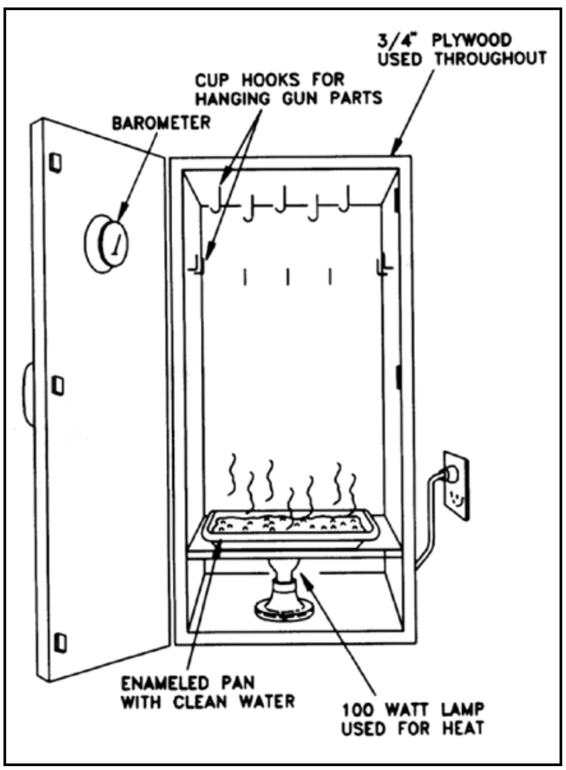

Figure 10: Details of a slow rust bluing cabinet – necessary in climates with insufficient moisture.

Figure 11: The Du-Lite. multi-tank bluing system is ideal for the professional shop. The same system can be used for hot water bluing as well as other methods.

The number of passes necessary to obtain the desired depth and uniformity of color will depend on the hardness of the metal. You may get by with as few as three passes on .22 caliber rimfire rifles, while nickel-steel barrels might require as many as 10 or 12, but the average will be five passes. After the metal reaches the depth of color desired, give the just-carded parts one more carding — this time using a steel-wool pad, saturated with an oil such as WD-40. Do not be afraid of wearing off the bluing with steel wool; this bluing is so tough you will not disturb it even with steel wool.

For easy reference, here is a checklist of steps to follow when slow rust bluing:

1. Disassemble the gun, separating parts to be blued from those that are not to be blued.
2. Remove all pits and deep scratches by draw filing.
3. Polish the metal parts using abrasive paper from size 80-grit to 500-grit. (See instructions under hot water bluing.)
4. Degrease the parts in a hot lye or other cleaning solution.
5. Boil the parts in clean water.
6. Apply the bluing solution evenly and allow parts to rust from 4 to 8 hours (more if necessary), but never overnight or longer than 12 hours.
7. Card off rust with steel wool, a stainless steel brush, or soft carding wheel on a power buffer.
8. Repeat the last three steps until the desired finish is obtained.

When the job is completed, you will know how much hard, meticulous work was required; and if you did your part well, you will also know that the finish on the rust-blued firearm equals, if not surpasses, the finest finish on any factory-blued model.

Once you have mastered the previously mentioned bluing methods, you will find the popular hot caustic bluing method a breeze to master. However, the other methods will still have a place in the gun shop.

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Hot Caustic Bluing

Unless you choose to be highly specialized in your gunsmithing work or you plan to do commercial bluing, you will eventually go to the hot caustic method of bluing firearms. This is the process used by the majority of firearm manufacturers, as well as most professional gunsmiths. The number of firearms that can be blued at one time, using this method, is limited only to the size of your bluing tanks.

A relatively good bluing job can be accomplished with just one bluing tank, a source of heat, some cleaning solution, and a few pounds of bluing salts. However, for the best results, especially for the professional, a six-tank system is best. Heatbath Corp., Du-Lite Corp., and Brownells all offer ready-to-install systems, all of which are easy to set up. There are few differences in the various systems and bluing salts available. All produce a "factory-type" finish on gun steel, as shown in Figures 12 and 13. The decision of which system to buy depends on individual preference towards service and price. The quality of the bluing job will depend almost entirely upon the gunsmith.

Figure 12: Different manufacturers use bluing salts from different sources. This Colt Diamondback was blued with salts obtained from Heatbath Corporation.

BLUING EQUIPMENT

Each tank should be at least 8 in. x 8 in. x 40 in. in size for the most efficient work. The tanks should be made of 11-14 gauge black iron or steel welded at the seams. Each tank should also be flanged around the open edges to prevent excess dripping or "creep." The oil tank must have a drain board attached to it and also a rack on which to hang guns and parts while the excess drips off.

A good quality drain plug on each tank also helps enable easy cleaning. If possible, each tank should be connected to a drain. The cold water rinse tank should have an overflow pipe and a water inlet pipe to provide the best possible work by providing a constant flow of fresh, clean water during the bluing operation.

The operator will need safety goggles or a face shield, a suitable apron, and rubber gloves. Black iron stovepipe wire is the favorite for suspending the parts in the bluing tanks. Never use galvanized wire. You will need an accurate thermometer that reads temperatures from 0° F to at least 310° F. A sufficient quantity of bluing salts, alkali cleaner, and hot soluble oil will complete

Figure 13: Firearms manufactured by the Winchester Repeating Arms (and more recently, U.S. Repeating Arms) have used Du-Lite hot caustic bluing salts almost exclusively.

the basic setup. In choosing the oil, be extremely careful to obtain the correct type. Some oils will ignite and are unsafe for heating. At least one gunsmith's shop has burned to the ground due to the oil in the tank igniting. Therefore, use only oils that are designed for hot caustic bluing and follow the directions supplied by the manufacturer or distributor.

Of course, new ideas and techniques are always being developed, but they should be approached with caution until they have been proven both safe and effective.

When using the six-tank system, work left to right with the following sequence of operation:

- Hot alkali cleaner tank
- Cold water rinse tank
- 285° F bluing tank
- 300° F bluing tank
- Cold water rinse tank
- Hot soluble oil tank

The hot caustic bluing process produces a black to blue-black finish on gun steel. The surface condition of the gun part will be the determining factor of the quality of the ultimate finish. Parts to be finished must be absolutely clean and free from oil, grease, and rust.

The gun parts may be cleaned by scrubbing with any good cleaner and hot water. If mild acids are used to remove rust or scale, the parts should be washed in soap and water to neutralize the acid.

With the six-tank system, cleaning is accomplished in tank No. 1, followed by a cold water rinse.

Making the Bluing Solution. To make a 6 in. depth of bluing solution, proceed as follows:

1. Start with about 3 in. of cold water in each bluing tank.
2. Add bluing salts in small quantities, allowing each quantity to dissolve thoroughly before making further additions, until about 30 lb. of material have been added to each tank.
3. Light the gas burner (half capacity at first, increasing as temperature approaches working temperatures).
4. Add cold water slowly through the splash guards (from the reservoir) until the depth of solution is approximately 5 in. and allow the solution to come to a boil.

6. Continue to add bluing salts to each tank until a boiling temperature of 285° F is obtained in the first bluing tank (tank No. 3). Also add salts to tank No. 4 until the boiling temperature reaches about 300° F.
7. After these temperatures have been reached, they are maintained by adding water slowly from a reservoir to compensate for the water lost through evaporation, making sure a good rolling boil is maintained at all times. Additional bluing salts are added only to maintain the desired working level of the solution.

Operating Procedure. The tank setup shown in Figure 14 is good for hot caustic bluing. Clean the parts to be blued by hand or immerse them in hot alkali cleaner. If using the alkali cleaner,

never leave parts in for more than one minute or they might rust. Parts can rust in the cold water rinse too; never leave them immersed for more than 30 seconds. After the parts to be blued have been properly cleaned by hand, or with the alkali cleaner in tank No. 1, and rinsed in tank No. 2, they are immersed in tank No. 3 (285° F tank) for 20-30 minutes. The parts are then removed from this tank and transferred to tank No. 4 for another 20-30 minutes. Do not let the parts dry off between tank No. 3 and tank No. 4. The work is then removed and rinsed immediately in cold water in tank No. 5 before placing in tank No. 6 for immersion into the oil bath. Boil the parts in the oil bath for about 20 minutes, then remove them. When they are cool enough to handle, wipe them off with a clean shop cloth. Reassemble the gun and the job is complete.

Barrels, magazine tubes, and similar parts can be suspended in the solution with black iron stovepipe wire. Smaller parts such as screws and pins can be placed in a black iron basket and immersed into the bluing solution. Make sure the basket is not soldered; it must be welded. And do not use galvanized or nonferrous metal.

Caustic bluing solutions are designed for bluing ferrous metals and their alloys only. Aluminum, magnesium, die-cast parts (including most of the investment casting receivers and frames), tin, galvanized metals, brass, and copper cannot be blued with this system. Furthermore, parts that are soldered with lead-tin (soft) solders, such as many of the double-barrel shotguns, cannot be blued by the hot caustic method.

If brass sights are attached to the barrel, they can be immersed without problems, but it is still best to remove them if at all possible.

Imitation Heat Blue. Most gunsmiths now use the hot caustic bluing method almost exclusively and seldom have the time to experiment with alternate methods. However, these same gunsmiths are often called upon to restore older firearms when the owner wants an authentic-looking metal finish. One hot caustic bluing formula

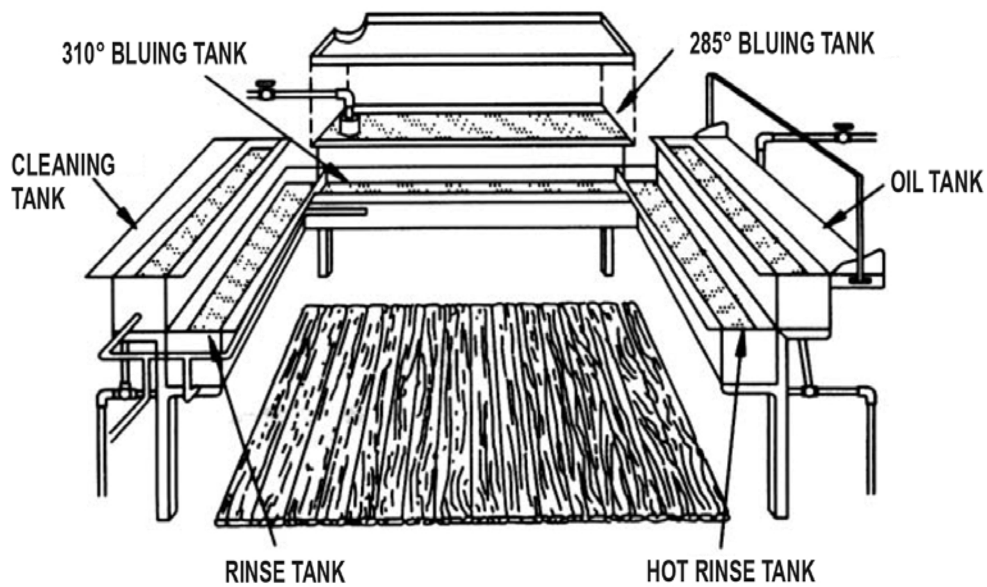

Figure 14: A setup like this can be used for niter bluing, hot water bluing, and hot caustic bluing.

that gives results close to the original niter blue is as follows:

To each gallon of pure water add a mixture of:

- 65 oz. sodium hydroxide
- 30 oz. sodium nitrate
- 5 oz. sodium nitrite

To mix, first determine the size of your bluing tank and the amount of water required to bring the water level up to about the halfway mark. Let's say, for example, this requires four gallons of water. Therefore, you would need four times the amount of chemicals described above: 260 oz. of sodium hydroxide, 120 oz. of sodium nitrate, and 20 oz. of sodium nitrite. Mix these ingredients together before adding them to the water. Add the four gallons of pure water to your bluing tank, turn the heat on low, and slowly add the dry powders, a little at a time, stirring the solution to help the chemicals mix with the water. Be sure to use all safety precautions as with any type of bluing: face shield, rubber gloves, apron, etc. If you add the chemicals too fast, the solution will heat too quickly and erupt or boil over. Let the chemicals dissolve slowly. The solution should start boiling at about 285° F. If not, add a little more water; if the solution boils at a lower temperature, add more bluing salts. However, when adding water, use a water shield and let the water trickle into the tank; too much will cause the solution to erupt. Always be cautious when adding either water or salts to the tank — especially water.

Once the solution is at a rolling boil and the temperature is between 285° F and 295° F, degrease the parts to be blued and suspend them in the bluing solution with black iron wires or in a suitable parts basket. Make sure all parts are at least 1 in. from the tank sides and bottom, and that the temperature of the solution does not rise above 295° F.

The time required to obtain the desired finish will vary with the type of steel. Some gun metal will color within 5 minutes, but other parts may take as long as 30 minutes. Inspect the parts about every 5 minutes until the desired color has been reached.

When the color is deep enough, remove the parts from the bluing solution and immerse them in clean, boiling water for about 5 minutes, let cool, and then oil with any conventional gun oil. You should have a rich blue-black finish very close to the original niter blue found on firearms manufactured 50-100 years ago.

This solution, like most hot caustic solutions, will destroy solder, brass, aluminum, etc. The action of nonferrous metals will also destroy the effectiveness of the solution. Small traces of sulfur in the water will do the same thing.

Be sure to take all precautions and use the recommendations for conventional hot caustic bluing when using this method. Commercial bluing solutions and outfits usually include instructions and precautionary measures.

TROUBLESHOOTING HOT CAUSTIC BLUING

Some types of firearms — U.S. Krag, Mauser, and some others — will often come out of the bluing solution with a reddish or purple tint. To avoid this, first bring the bluing salts up to normal operating temperature. This is to make sure that the salts are of the correct concentration. Then lower the temperature of the bath by cutting back the heat of the burners and allow the solution to cool down to about 235° F. When this temperature is reached, immerse the barrel/receiver and other parts in the salt bath. Then turn the heat up slightly and bring the temperature of the bath back up to the normal operating temperature, but make certain this is done very, very slowly. The receiver and other hard parts will blue at the lower temperature and the softer parts at the upper temperature. After the receiver has blued at the lower temperature no harm is done to the surfaces by the higher temperature.

Frequently, a green film will form on the surfaces of the metal parts, caused by the bath temperature being too high for a particular type of metal. This film can be removed by gently carding the metal surface with steel wool and water while the parts are held over the cold water rinse tank. Once removed, the parts can then be put back into the hot bluing tank and continued to blue after lowering the operating temperature.

To ensure the best possible bluing jobs, closely adhere to the following:

- Clean the oil and film from top of water tanks.
- Use a magnet to check if the parts are steel.
- Keep baskets and black iron wire clean; do not set in oil.
- Avoid bluing springs if possible.
- Wear safety goggles or a face shield at all times.
- Do not allow metals to stay in cleaner or hot rinse too long; doing so will cause rust.
- Do not plug barrels when bluing by the hot caustic process.

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Browning Gun Metal

In the early history of firearms, guns that were exposed to the elements became covered with a brown coating, a result of iron oxide or red rust. When rubbed, the loose, top layer of rust came off, but the stained metal remained brown. Each time the gun metal was rubbed, a deeper and more even hue of brown appeared. This coloring process provided a functional camouflage since the new metal did not flash or reflect light.

The concept of browning—coloring the gun brown by letting rust collect on the metal—was very popular by the 1700s. Many gunsmiths had perfected ways to cause rust to form on the gun metal. Usually, the rusting process was accelerated by using a salt and water solution on the metal. The rust was then removed using steel wool (a process called carding). Numerous coats of the solution were applied to the gun metal, and the resulting rust carded until the preferred color finish appeared.

The basic browning process is still used today to restore old firearms to their original finish. Shotguns with twist steel or Damascus barrels, like the ones shown in Figure 15, or muzzle loading firearms, shown in Figure 16, require browning as a part of their restoration. Many modern black powder guns are refinished using the browning process.

The professional gunsmith should have a good knowledge of browning techniques. This lesson describes several browning techniques that are economical and reliable.

BASIC BROWN

A simple browning technique requires a solution to table salt and distilled water. Add 5 tablespoons of common table salt to a pint of distilled water. Mix with a glass rod and store in a clean bottle or jar.

The metal to be browned is prepared by removing all the old rust and finish (in the case of refinishing) and by polishing the metal to the preferred luster, either by hand or by using power equipment.

Figure 15: Damascus barrels consist of a combination of forged iron and steel, which is braided in different forms into a band. This band is then wound around a mandrel and welded to form shotgun barrels. The technique has not been used on new firearms since the turn of this century.

Figure 16: Early flintlock pistols all contained a brown, rather than blue or blue-black, finish. The style continued until the latter part of the last century.

Make two wood dowels that fit in both ends of the barrel. Thoroughly grease the bore with gun grease, pump grease, or similar grease to prevent the inside of the barrel from rusting. Drive the wood dowels tightly into the ends of the barrel, as shown in Figure 17. If the shotgun barrels are thin, do not drive the wooden plugs in too tight; you might split the end of the barrel.

Next, degrease the metal parts with a commercial cleaner or by boiling them in a solution of commercial cleaner and water. Once this is done, your bare hands should not touch the parts until the process is completed. Wear rubber gloves as a precaution, but handle the parts only by the wooden dowels or by black iron wires attached to the parts.

If you have iron tanks large enough to hold all of the parts to be browned, the grease and oil can be removed by boiling the parts in a solution of water and lye, measuring 1 tablespoon of lye per gallon of water.

Once cleaned, liberally swab on the salt solution with a cotton pad or sponge. Make sure that all surfaces are covered. Try to avoid runs and streaks because they will show up on the dried parts.

Let the metal parts rust. If you have a basement that is cool and damp, simply hang the parts there to let them rust for 12 hours or more or until a coat of coarse rust has formed on all metal surfaces. If you live in a relatively dry climate, the rusting process will take much longer. However, you can overcome the elements and construct an ideal setting for browning a gun. Build a small wooden box large enough to hold the metal parts. Line the box with wet burlap sacks. Place the parts in the box so that they are suspended in mid-air – they must not touch the sides or bottom. Cover the box and let the parts rust until the desired coarse rust has formed. This usually takes 6-12 hours.

Use 00 steel wool that has been cleaned thoroughly so the oil that is usually applied at the factory to prevent rust during shipment is stripped off. Card off the rust that has formed on the metal parts. Use a stainless steel brush (that has also been cleaned) to get into tight places. When all of the loose rust has been removed, apply more of the salt solution to the parts and let them rust again until a coarse rust forms on the surface.

Repeat this process 10-12 times or until you get the desired shade of brown. This last carding should be done very thoroughly. Make sure you get every bit of rust off the metal surfaces, around crevices, etc. Then boil the parts in water for about 20 minutes to stop the rusting process.

Figure 17: Barrels should be plugged with tapered hardwood dowels to prevent water from entering the bore and to allow a means for holding the barrel.

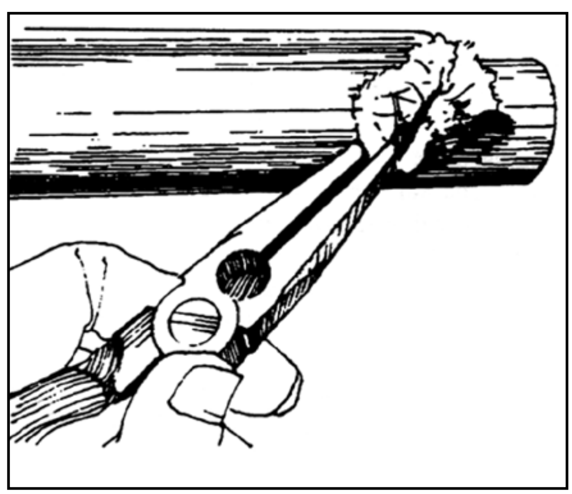

Figure 18: A pair of long-nosed pliers is used to hold a clean piece of cotton to apply the browning solution.

While the parts are drying, immediately coat all surfaces with a good gun oil.

The exact shade that results from the above method will vary. It depends upon the type of metal and the number of times the solution is applied. In general, though, the color of brown is the shade of muddy water. To improve the appearance, soak the parts in a very weak solution of copper sulphate and distilled water prior to oiling the parts. Use a solution of .02 percent copper sulphate in the distilled water. The resulting finish will be a plum brown, which is desired on antique weapons like old Kentucky rifles.

Since rust browning is not an exact science, the color will sometimes vary to extremes. For example, after the parts are boiled for 20 minutes in water following the last solution coat, the parts might turn blue or blue-black. To absolutely prevent the parts from turning this color (it will not happen often), pour hot water over the metal parts before oiling and do not boil them. Immediately pour the gun oil to the surface, and continually inspect the metal to see if more rust appears. If more rust does appear, card it off and add more gun oil to the metal surface.

DIXIE GUN WORKS FORMULA

Dixie Gun Works Inc. has a good and inexpensive commercial solution for browning, made according to a 100-year old formula. It can be substituted for the salt water in the salt water solution method or the solution can be immediately applied to heated parts. This solution is especially useful on some Damascus twist barrels.

To use the Dixie Browning Solution, first prepare the metal surfaces by polishing. Grease the bore and plug the barrel with wooden dowels. Drive the dowels in tightly, but loose enough for easy removal. Degrease the parts with a solution of baking soda and water. Once the parts are degreased, wash them with clean water and let

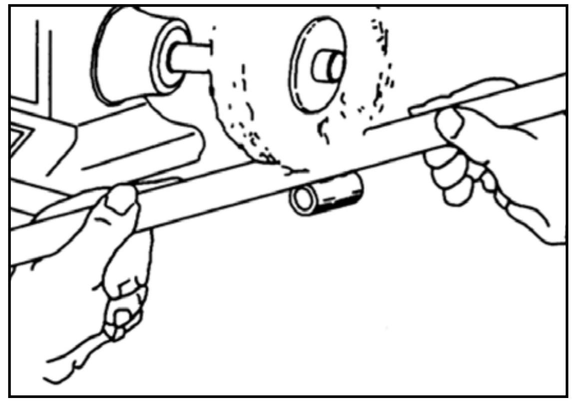

Figure 19: Steel wool can be used for carding the loose rust between browning applications, but a power-driven wire wheel is better – especially for the last carding operation.

them dry. As with all rusting types of bluing, the parts must not be touched with bare hands during the browning process. Handle the parts by the wooden dowels or use iron wires. Wear clean cotton gloves or rubber gloves to make sure your skin does not come into contact with the parts.

Holding a clean cotton swab or a cotton ball with a pair of long-nosed pliers, as shown in Figure 18, or a clothes pin, dip the cotton into the browning solution and squeeze it against the side of the bottle, leaving only a small amount on the swab. Apply the solution to the gun parts sparingly and evenly until all surfaces are covered. In 6 to 12 hours, a thin red rust will form on the metal surfaces. (In extremely dry areas, construct a "sweat box" as previously described).

Once rusted, card the parts with 00 steel wool and a stainless steel brush until all of the loose rust is removed, as shown in Figure 19. Do not remove too much rust or you will expose the bare metal. Remove only the loose rust. Practice will determine just how much rust to remove. Repeat the application and carding processes until the

preferred shade of brown appears. However, do not wait as long (6-12 hours) between cardings as you did for the first coat.

The final carding should be done very thoroughly. Stop the rusting process by boiling the parts for 20 minutes in water or by wiping very carefully with hot soapy water.

Let the parts dry and then coat them with lubricating oil. When the parts cool, wipe off excess oil and let them stand in a warm room for 24 hours before handling.

Dixie Gun Works explains that, with a little practice, anyone can turn out a professional-looking job with this browning solution. It is even possible to bring out the twist steel patterns frequently found in old Damascus shotgun barrels.

The color and rusting time required will depend on the humidity, room temperature, and the type of steel or iron being browned. The process can be hastened by heating the part. Heating the part to be browned produces an instant brown color, but this color might not be as durable nor as attractive as the color produced by the slower process.

Figure 20: The main items for browning gun steel with the Laurel Mountain Forge Barrel Brown and Degreaser are the browning solution, applicators, and the parts to be browned.

LAUREL MOUNTAIN BROWN

The Laurel Mountain Forge Barrel Brown and Degreaser, shown in Figure 20, is available from Brownells. Again, the metal parts to be browned must be prepared the same way as any other metal parts prior to browning. The surface of the metal must be perfect before the browning solution is applied.

In most methods of bluing or browning gun metal, it is necessary to make sure that all parts are absolutely free of grease, oil, or foreign matter. Once the procedure starts, be careful not to touch any of the parts to be browned with your hands. The Laurel Mountain solution has a degreaser included in the solution, but it is still recommended to degrease the metal before applying the solution.

Begin by oiling the bore of the gun to prevent the inside from rusting. Seal the bore with tightly-fitted plugs made of rubber, plastic, or wood.

To apply the solution, use a piece of cotton cloth folded in a pad four layers thick and about one inch square. Moisten the pad thoroughly with the browning solution and apply it to the barrel. Be sure to apply the solution in long, even strokes from muzzle to breech. After applying this first coat of browning solution, set the barrel aside for 3 hours to allow the solution to work. Then apply a second coat. Make certain your applicator is only damp. If too much solution is applied after the first coat, it might remove some of the previous coat, causing the finish to be uneven or spotty.

Figure 21: This Model 1873"Trapdoor" Springfield rifle was browned at the United States Armories before it was released to troops. If you want to restore such firearms, you must know how to brown gun metal.

After leaving the second coat on for 3 hours, rub the surface of the barrel or other metal part with a piece of coarse cloth, like an old towel, dipped in hot tap water. This removes the surface scale that has built up and "evens" the brown; it is similar to carding in conventional slow rust browning methods.

After scrubbing the barrel, flood the surface with hot tap water and dry. Do not boil the parts. The surface will turn black, rather than brown, when boiled. Repeat the cycle of applying the browning solution, leaving it on the part for 3 hours, and scaling the barrel until the desired color has been achieved. This will probably take 4-5 coats.

If you cannot get back to work within 3 hours, do not apply another coat after scaling. Just scale the barrel and put it aside until you are ready to resume browning.

To stop further action after achieving the desired finish, scrub the surface of the barrel using hot tap water with a little baking soda. Rinse the barrel with clear warm water and allow to dry. To finish the barrel, apply wax or boiled linseed oil.

If a rougher antique finish is desired, apply wet coats of the browning solution to the surface at 12-hour intervals. When leaving the solution on the metal this long, usually 2-4 coats is sufficient, depending on climate conditions. To maximize roughness, do not scale the surface between coats. After the desired depth of color has been obtained, wash the browned parts with water and baking soda in the normal manner to stop further browning. This method works especially well on small parts.

If you would rather have a rust blue finish instead of a brown finish, the Laurel Mountain solution can still be used. Just boil the parts in pure water between scalings. Boil each part for 5 minutes or until the finish darkens. Scale the parts as discussed previously. Repeat the process until you have the desired hue.

BROWNING OLD MILITARY ARMS

During the mid-1800s, the U.S. armories browned the barrels of all rifles, like the 1873 Springfield shown in Figure 21, prior to releasing them to service. However, the locks, ramrods, band springs, triggers, and screws were not browned during this period. They were normally case-hardened and oiled.

The solution used by U.S. armories during this period contained the following ingredients:

- 1½ oz. grain alcohol
- 1½ oz. tincture of ferric chloride
- ½ oz. mercuric chloride
- 1½ oz. ethyl nitrate
- 1 oz. copper sulfate
- ¾ oz. nitric acid

Mix and dissolve these ingredients in a quart of soft water; store in a dark glass bottle.

In mixing this solution, you may have trouble finding ethyl nitrate. This chemical has recently been taken off the market. Several experts prefer to omit this chemical since the results are the same with or without ethyl nitrate. However, the process might take a little longer if ethyl nitrate is not used. Many gunsmiths prefer to use a 2 percent nitric acid solution in distilled water, which produces the same results as the ethyl nitrate solution.

Polish the parts to be browned in the usual manner, then carefully clean them. A small quantity of powdered lime rubbed over the entire barrel will degrease the metal sufficiently. Use wooden plugs to plug the muzzle of the barrel and the vent hole.

Apply the solution to the barrel in even strokes, using a clean sponge or rag. Expose the barrel to air for 24 hours, then card it with steel wool or a wire brush, removing all loose rust. Be careful not to remove the stain on the metal beneath the loose rust.

The mixture is then applied again to the metal, and, in a few hours, the barrel is sufficiently corroded for carding. The same process of carding the metal and applying the solution should be repeated 2-3 times a day for 4-5 days, by which time the barrel will be dark brown.

Figure 22: Birchwood Casey Plum Brown Barrel Finish is one of the many instant browns on the market.

When the barrel is sufficiently brown and the rust has been carefully removed from every part, about a quart of boiling water should be poured over all parts so that the action of the acid mixture upon the metal is destroyed, and the rust is prevented from rising. When the barrel cools, it should be rubbed with linseed oil.

You might want to varnish the browned gun parts after applying the linseed oil. To do so, mix 1 oz. of shellac with .1857 oz. of dragon's blood (resin extracted from fruit) and a quart of alcohol. Apply to the browned metal.

To remove old browning, varnish and grease the parts, and plug the vent and the muzzle of the barrels. Immerse the browned parts for one hour in boiling lime water or lye (about one tablespoon per gallon of water). Wipe dry and put the barrel and other parts in vinegar, held in a plastic trough, for about 45 minutes. The browning can then be rubbed off with a rag.

INSTANT BROWNING SOLUTIONS

There are several instant browning solutions, like the one shown in Figure 22, and they are basically used the same way. In general, the parts to be browned are first polished and cleaned. A propane torch or other heat source is then used to slowly heat the parts just enough to "spat" a drop of water (about the same temperature as a regular clothes iron). After reaching the correct temperature, the browning solution is applied in thin, even strokes with a cotton swab. The surface of the metal is then left to rust for about 15 minutes.

Flush the surface of the metal with hot water. When dry, lightly card off the loose rust that appears. Heat the metal once again, and apply the browning solution as before. Let the solution work on the metal for 10-15 minutes. After this, flush with hot water and card. Repeat these steps until you have the desired finish.

When using the instant browning solutions, the manufacturer recommends not to cover a very large area all at once because the metal must be evenly warm to accept the finish. One of the best sources of heat is an old kerosene lamp held under the metal parts until they reach the preferred temperature. Although you can use a propane torch, the part can get too hot and the finished job will be spotty.

Remember that most of the chemical browning solutions are poisonous and can be harmful if misused. Read and follow the instructions on each container carefully.

SPECIAL CASES

Twist steel or Damascus barrels are ideal candidates for browning. Browning brings out the beautiful wavy patterns of the twist. However, after using any of the slow rusting methods described previously for the twist steel or Damascus barrels, the patterns might not show up very well. In these cases, additional treatment is necessary to bring out the full beauty of the twist pattern. First, rub the barrels with a linen rag that is coated with chalk paste or any fine abrasive powder. Wipe the barrels clean and oil with gun oil or use conventional paste wax. However, for such specialized work, the gunsmith must have sufficient experience before attempting to work on a very detailed, fine arm. Since there are so many pattern variations, a gunsmith has to know and recognize the pattern in order to solve a specific problem.

MARK LEE EXPRESS BROWN

The Mark Lee Express Brown #2 formula is becoming very popular with professional gun shops for obtaining either a soft, velvety sheen or a high luster brown on firearms of all types.

To use the Mark Lee formula, first prepare the metal surface as discussed previously: polish and degrease. Degreasing is essential in getting fine results. Pre-clean the parts by soaking them in a solvent, such as lacquer thinner. After this, soak the parts in an industrial strength alkali cleaner such as Brownells' Dicro-Clean No. 909. Scrub the parts with a brush during the cleaning process.

Remove the parts from the cleaning solution with tongs or hooks; never touch them with your bare hands at any time during the browning process. Rinse the parts with hot water and then immediately dry with compressed air, a hair dryer, or blot them with paper towels. Wear either clean cotton gloves or surgical gloves during the entire operation to prevent body oils from contaminating the metal.

To continue the browning operation, you will need the following:

- Cellulose sponge or cotton swabs
- Small plastic or glass container
- Propane torch, heat lamp, or some other heat source
- Fine steel wire brush (.003-.005 in.) or very fine degreased steel wool

Pour the browning solution into a small glass or plastic container. Warm the metal parts to be browned to about 200°F with your heat source. Dip your applicator (sponge or cotton swab) in the browning solution and apply very thin coats to the warmed parts. A coating of rust will immediately form. Allow the solution to dry (approximately 30 seconds). Now use fine (0000) steel wool to remove the loose residue on the metal. Make sure all residue is removed, but do not rub too hard or you will remove the faint brown color underneath.

Warm the parts again, apply a thin coat of the browning solution, let them dry, and then remove the loose residue with steel wool. Repeat this step 6-10 times until the desired color develops.

Almost any shade of brown to black can be obtained with the Mark Lee formula by using hot water and varying the number of coats applied. For example, if you want a deep brown color, apply the browning solution to the warm parts as discussed previously. After building four to six coats on the metal parts, continue to apply additional coats, but rinse the parts in very hot tap water between each application. If you want black parts, boil the parts for about 20 minutes after the last coat.

Once you have the shade on the metal parts that you want, you must neutralize the browning action. To do so, soak the browned parts for 1½ hours in a solution of 1½ lb. of baking soda to each gallon of water at room temperature. After soaking, remove the parts, rinse with hot water, and dry. If necessary, remove any remaining residue with a terry cloth towel, fine steel wool, or a wire brush. To complete the job, oil the parts with a good gun oil.

WATER FOR BROWNING

Many experts believe that pure water is absolutely necessary for the best browning and bluing jobs. Chemicals added to city water supplies might have an adverse effect on the final results, such as visible light streaks. Hard well water can do the same thing. In the slow rusting methods of bluing or browning, using distilled water is highly recommended. If you only do the occasional bluing or browning jobs, then it would be best to just purchase several gallons of distilled water.

Another way to get pure water is to have your pharmacist order a water deionizing column. This is a clear plastic, cylindrical container packed with purification crystals. There are couplings at either end for surgical tubing. Simply run tap water slowly through the column into a clean receptacle — a clean plastic or glass jug works well. Deionizing columns come in various sizes; the larger the column, the greater the expense. However, if you plan to do a fair amount of browning or rust bluing, the money spent is worth it.

A filter can be connected to the plumbing to purify the entire water system for a faster rate of water supply. Of course, this type of filter is quite expensive. For a gun shop that turns out many rust-blued jobs each week, a high-end water filtration system is the best way to go.

Coloring Stainless Steel

Stainless steel barrels are not new. The Winchester Repeating Arms Co. introduced stainless steel barrels for their famous Model 12 slide-action shotgun, shown in Figure 23, many years ago. Cold mineral acid was sometimes used on stainless steel barrels to color them. However, contamination of the surface from smut and the possibility of dimension loss have made the use of acid obsolete in coloring gun barrels. When the blackening wore off these barrels, most gunsmiths of the day used flat black paint and did not oxidize the steel.

However, in the past twenty years, many stainless steel guns have come out on the market. Many of these are left in their natural "mill finish," while others have been colored by a blackening process.

One blackening method used for stainless steel guns is known as the Du-Lite 3-0 process. To set up the Du-Lite 3-0 process to blacken stainless steel, you need equipment similar to what is used in the conventional hot caustic process. You need an alkaline cleaning bath (Du-Lite #45 or an equivalent) heated to 180˚F or higher with an active running water rinsing tank. A surface activator solution, either hot or cold, is also needed.

In general, a Du-Lite 3-0 blackening bath is made in an externally heated steel tank. Concentration of the bath must be regulated to obtain a boiling solution (240˚-250˚F). This will require 4½-5 lb. of Du-Lite 3-0 salts per gallon. A convenient method of making up the bath is to fill the tank to about one-half of final capacity, then add 3-0 salts with constant stirring until the desired temperature of the boiling solution is obtained. Continue to add salt and additional water until the working level of the solution is reached. With 400 series steels, the best result is usually obtained at a boiling point of 245˚F or above. With 300 series steels, a temperature of 240˚- 245˚F usually is most satisfactory. If the temperature is too low and the bath is boiling, add more salts.

If steels in the AISI 400 series (no nickel) are to be processed and rigid dimensional tolerances are to be observed, color these steels with Du-Lite Aldak 30, an alkaline medium. The solution is made at a strength of 3 to 4 lb. per gallon. It is contained in an externally heated plain steel tank and the temperature must not exceed 240˚F. The 400 series steel is placed in the hot Aldak 30 solution and held there until a gray cast appears. This should only take about 15 minutes. Remove the work at once, rinse in cold running water, and then place in the 3-0 boiling blackening bath for 30 minutes. When the color is satisfactory, the work is removed, dried and left unfinished, or lightly brushed on a Tampico Wheel.

Figure 23: The Winchester Model 12 slide-action shotgun was one of the first firearms to come from the factory with a stainless steel barrel. This same model, however, was also offered in conventional Winchester Proof Steel.

EBONOL SS-52

Ebonol SS-52 is another alkaline, oxidizing-type blackening compound, which produces black coatings on stainless steel and high-alloy steels normally difficult to blacken. Ebonol SS-52 solutions produce a mixed oxide-sulfide black coating by simple immersion.

The appearance of the black finish is dependent upon the surface of the steel being coated. Shiny black coatings are produced on buffed or polished surfaces. Uniform matte coatings are produced on brushed or etched surfaces.

The dimensional changes involved in blackening are extremely small (less than 0.01 mil.). The thickness of the black oxide coating ranges from 0.06 to 0.1 milliliters.

Ebonol SS-52 is supplied as a powder and is shipped in 30-, 125-, and 400 lb. drums. The powder is dissolved in water to make the operating solution about 4¾ lb. of powder to one gallon of water. The operating temperature is 250˚-260˚ F, and the metal is colored within 5-15 minutes.

Mixing. Clean the tank thoroughly before making up the solution. Be sure all rust and scale is removed since rust will dissolve in the blackening solution and will tend to redeposit on the work, causing a red film.

Fill the tank about half full with cold water. While stirring with an iron paddle, slowly add 4¾ lb. of Ebonol SS-52 for each gallon of final solution. Continue stirring until the salts are almost completely dissolved; no solid lumps of salts should be on the bottom of the tank.

Add water to raise the level 2 in. above the desired solution level; do not fill to the final level because the solution expands on heating. Apply heat, and continue to stir until the solution comes to a boil. The Ebonol SS-52 solution should start to boil at 250˚F. If boiling occurs below 250˚F, slowly add Ebonol SS-52 salts while heating until the desired boiling point is obtained. Then, lower the heat input so that the solution boils gently.

Figure 24: Blackened stainless steel SR9c compact 9mm pistol.

Temperature. The blackening solution must boil within the recommended operating temperature range, 250˚-260˚F. The solution will boil at other temperatures if the concentration of the salts is not correct, but successful blackening will not occur.

As water evaporates from the bath, the solution will become more and more concentrated and the boiling point will rise. When the boiling point reaches 260˚F, water must be added to dilute the solution, which will lower the boiling point to 250˚F. Do not try to adjust temperature by means of heat input. The temperature of a liquid in an open container cannot exceed its boiling point. Control of the boiling point is done only by the addition of water (or salts if the boiling point is too low). The heat should be adjusted so that the solution always boils with a gentle roll. However,

when adding water, remember that the solution operates above the boiling point of water. Be careful when adding water to avoid spattering and eruption of the solution.

The boiling point is controlled by the addition of water. Thus, an automatic temperature controller that regulates water input instead of heat input will maintain both the correct boiling point and the correct concentration of Ebonol salts.

Operation. Work to be blackened must be clean and free of all rust and scale. The following cleaning cycle is recommended:

- Soak clean in hot alkaline cleaning. Rinse in running water.
- Activate in 50 percent muriatic acid at room temperature for 30 seconds-5 minutes.
- Rinse in running water.
- Blacken in Ebonol SS-52 for 5-15 minutes at 250°-260°F.
- Rinse in running water.

It is important that the steel is properly activated prior to blackening. The required immersion time in the 50 percent muriatic acid varies from 30 seconds to 5 minutes, depending upon the particular alloy and any surface treatment it might have undergone.

COLORING MISCELLANEOUS METALS

As more aluminum and other non-steel parts are used in modem firearms, more and more gunsmiths are faced with the problem of coloring the non-steel parts while the rest of the gun is blued. Aluminum parts absolutely cannot be put through the hot caustic bluing tanks because they will melt. Anodizing is the only way aluminum can be "blued."

Anodizing is the process by which aluminum is coated with a layer of oxide by giving the aluminum electric charge in an appropriate solution. The process is conducted in either a chromic acid or sulfuric acid solution. The chromic acid process is seldom used to color gun parts because the parts are usually dyed black. In each method, the hardness and porosity of the coating can be controlled by the concentration, temperature, and current density. The protective value of the coatings can be improved by sealing, which consists of treatment with hot water containing chromates, or with live steam. This hydrates part of the aluminum oxide and seals the pores. Coatings made in sulfuric acid can be dyed with organic compounds to produce colors (many of which are resistant to sunlight).

Unfortunately, the expense of setting up a complete anodizing system is too great for the average gun shop. However, there are ways of achieving the same results without the anodizing system.

The most obvious solution is to send the aluminum parts to firms specializing in anodizing aluminum, and do the remaining work on the steel parts (bluing or browning) in your shop. When you get the parts back (in about 30 days) you can combine them with the parts you blued to reassemble the gun.

Birchwood Casey's Aluminum Black, shown in Figure 25, is one blackening agent on the market that is used like cold touch-up blue. It produces a gray to black finish immediately and requires no special equipment. It is hard to get an even finish on large parts and should be used only for touch-up work.

Figure 25: Birchwood Casey Aluminum Black is used like cold touch-up blue.

To use Birchwood Casey's Aluminum Black, first degrease the part with some type of cleaning solvent. Remove the oxide with 00 steel wool before applying the solution. Once the surface is clean, apply the Aluminum Black solution generously to all surfaces with a cotton swab. Allow one minute for the chemical to work and then wipe lightly with a clean cotton cloth until the surface is dry. After it is thoroughly dry, polish the surface with a clean, soft, dry cloth to remove the adhering powder.

If a darker shade is preferred than was obtained with the first coat, apply more solution, wipe dry, and polish again. These steps can be repeated as often as necessary until the desired color is obtained. Apply a wax or oil to the surface once the last coat is applied.

From time to time, the gunsmith will be asked to color certain gun parts a color other than black or blue-black. These jobs will be infrequent, but it is good to know how to do this. The following formulas and methods have been used over many years successfully. However, some experimentation might be required to obtain the desired color, shade, etc.

CAUTION: Please bear in mind that many of the chemicals used in the following formulas are dangerous for home use. Whenever possible, have them mixed by a pharmacist, chemist, or other qualified person.

Blackening Aluminum. Mix the following solution to blacken aluminum:

- 1 oz. of white arsenic
- 1 oz. of iron sulphate
- 12 oz. of hydrochloric acid
- 12 oz. of distilled water

Mix the dry powders first and then add the acid. Carefully and slowly, pour the acid solution into the distilled water.

Clean the aluminum part to be colored with pumice and water and then place it in a commercial cleaner such as Dicro-Clean No. 909 and rinse immediately. Immerse the part in the above solution, which should be slightly warmed, until the part turns black. Polish lightly with fine steel wool and wax or oil.

Blackening Brass. Dissolve bits of copper scraps in nitric acid diluted with an equal amount of distilled water in a glass container. Be careful with the nitric acid because it is extremely caustic. Do not breathe the fumes! Immerse the brass object in the solution until it turns the desired hue. Remove and wash well with water. The brass will be a dull black. If a sheen is preferred, rub the finish with linseed oil.

Black on Brass. Dissolve 1 oz. copper nitrate in 6 oz. distilled water and apply to the brass. Heat the brass. By heating, the copper nitrate changes to copper oxide, producing a permanent black

finish. Instead of heating, the following solution can be applied over the copper nitrate coating:

- 1 oz. of sodium sulfide
- ½ oz. of hydrochloric acid, concentrated
- 10 oz. of distilled water

Mix by first dissolving the sodium sulfide in the distilled water and slowly add the hydrochloric acid to the mixture. When applied to the copper nitrate coating already on the metal, it changes the coating to black copper sulfide.

Golden Matte on Brass or Copper. Carefully immerse the object in a solution of one part concentrated nitric acid and three parts water in a glass container. Rock the solution gently. Wipe the object clean under running tap water. When dry, polish the surface with wax or lacquer.

Antique-Green Patina on Brass or Copper. To obtain this type of finish, mix the following solution:

- 3 oz. of potassium bitartrate (cream of tartar)
- 1 oz. of ammonium chloride
- 7½ oz. of copper nitrate
- 3 oz. of sodium chloride (table salt)
- 13 oz. of boiling water

Dissolve the salts in the boiling water and apply the hot solution to the object with a piece of sponge or clean rag wrapped on a stick. When the desired effect is obtained, wash and dry.

Another method of achieving the antique-green patina finish on brass is to paint the object daily for three or four days with the following solution:

- 3 oz. of copper carbonate
- 1 oz. of ammonium chloride
- 1 oz. of copper acetate
- 1 oz. of potassium bitartrate
- 8 oz. of strong vinegar

Yellow-Orange, Blue, Red-Brown on Brass. To get colors ranging from yellow to blue, immerse the object in the following solution. Increase the concentration for more blue tones.

- ½ oz. of sodium hydroxide (lye)
- 1 oz. of copper carbonate
- 24 oz. of hot water

If you want red-brown shades, briefly dip the object in the following solution:

- ¼ oz. of copper carbonate
- 7½ oz. of household ammonia
- ¼ oz. of sodium carbonate (baking soda)
- 48 oz. of water, near boiling

Cold-rinse the object and dip for a moment in diluted sulfuric acid (very carefully). Experiment for different shades.

Bronze on Copper. Mix the following solution to get a bronze finish on copper.

- 1½ oz. of ferric nitrate
- 1-2 oz. of potassium thiocyanate
- 32 oz. of distilled water

Heat the solution. The metal object must also be heated before immersing in the solution. This can be done by dipping the object in hot water. When the object is hot, dip in the chemical solution until the color is satisfactory. Rinse in running water and dry in the breeze of a fan.

Red-Bronze to Brown on Copper. To change copper to this color, mix the following solution:

- ½ oz. of sulfurated potassium (liver of sulfur)
- ¾ oz. of sodium hydroxide (lye)
- 32 oz. of distilled water

Heat the solution and dip the object in it. When the preferred color appears, rinse, dry, and lacquer.

Steel-Gray on Aluminum. To change aluminum to this color, mix the following:

- 8 oz. of zinc chloride
- 1 oz. of copper sulfate
- 32 oz. of boiling water

Immerse the object in this solution until the preferred tone is obtained. Rinse the parts carefully in a 2 percent solution of lye in water and then rinse thoroughly in clear water.

Near-White and Matte Colors on Aluminum. A soft-etched, imitation anodized finish on aluminum can be achieved by dipping the part in a solution of 1 tablespoon or more of lye to a pint of water. To color the aluminum, dip the part in a household dye solution. Rinse in hot water, dry, and coat with wax or lacquer.

NOTES

NOTES

Beautiful engraved metal plates by Wm. Gamradt.

Introduction

Metal plating has been applied to firearms, mainly on handguns, for quite some time. However, with the appearance of stainless steel handguns and rifles, the metal plating process has lost some ground in the past few years. Still, most gunsmiths will get calls for plating jobs (mostly handguns) from time to time, and every practicing gunsmith should at least have a good knowledge of how the various jobs are accomplished.

There are firms that specialize in metal plating, and many gunsmiths merely farm out the work to these firms, rather than setting up for this process themselves, especially if the gunsmith has only a few jobs each year.

Parkerizing is another metal coloring technique that was first used by the U.S. Government on their Springfield service rifles to provide a more durable, rust-preventing finish than was possible with bluing or other metal-finishing processes of the time. The process consists of boiling the gun parts in a solution of powdered iron and phosphoric acid. In the process, minute particles of the parts' surface are dissolved and replaced by insoluble phosphates that give a gray, nonreflective, and rust-resistant finish. When Cosmoline is applied immediately after the process, the finish often turns green.

While Parkerizing is considered by many to be less attractive than conventional bluing on highly polished steel, it is far more practical from a military point of view.

Some private firms are now specializing in Parkerizing firearms and most are doing a substantial business in restoring military weapons and giving porting firearms a nonreflective matte finish.

This lesson is designed to familiarize you with both techniques; that is, metal plating and Parkerizing. A good knowledge of both will put you one step closer to being a professional gunsmith.

Metal Plating

Nickel plating has long been a favorite finish for many handguns. It provides decorative effects, protection against rust and corrosion, and a wear-resisting surface. Although nickel has been the traditional favorite, other metals such as chromium, gold, silver, brass, and copper are also used. Chromium, for example, when applied to metal gun parts provides a surface harder than the hardest steel. It protects the base metal, reduces wear, lessens friction and, at the same time, provides an attractive appearance.

Most metal plating is accomplished by a process called electroplating, shown in Figure 1, which uses an electric current to deposit the plating over the base metal. In general, the object to be plated becomes the cathode (negative plate) in an electrolyte cell that contains (in some chemical compounds) the type of metal that is to be plated onto the base material. Anodes (positive plate) are used on all sides of the object so that electricity may flow from all directions to the article being plated and cause an even deposit of the plated metal. The exact chemicals, currents, voltages, temperatures, and general procedure will vary with the kind of metal being plated and the method used. For example, nickel plating often is done with an electrolyte-containing nickel sulphate or nickel ammonium sulphate, with the ammonium sulphate added to increase the conductivity; the addition of acid helps keep the anode rough; and something like glue or glucose rounds out the formula to make the plating extra bright. The anodes may be made of some material, such as carbon, which is not affected by the electrolytic action. When using this method, all the plated metal must come from the electrolyte and chemicals containing this metal must be added to the liquid at various intervals.

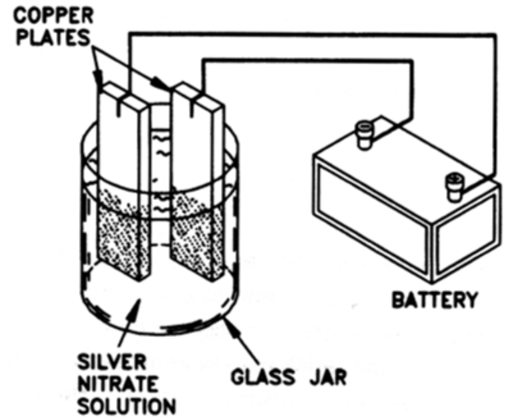

Figure 1: When plating, anodes are used on all sides of the object being plated so that the electricity may flow from all directions to that object so that an even deposit of plated metal results.

Figure 1A: Metal plating on Colt 10-gauge double-barrel shotgun.

In other plating methods, the anode is made of the plating metal. For example, in plating with brass, the anode is made of brass. The brass dissolves from the anode into the electrolyte that is deposited from the electrolyte onto the cathode, or object to be plated. The object of this method is to get metal dissolved into the bath (electrolyte) as quickly as it plates out. As the anode metal dissolves, it generates a voltage; just as dissolving a metal generates a voltage in a conventional storage battery. Under ideal conditions, this generated voltage would equal the voltage consumed in depositing metal onto the cathode, so the external source would need to provide only enough voltage to overcome the resistance in the cell and the connections.

Before we get into the plating process, it should be observed that you may not want certain areas of a gun plated. A good example would be the sear engagement areas on a handgun hammer and trigger. Until recently, you had to plate those parts and then redress them to work as perfectly as they did prior to plating. Now, with the development of stop-off lacquer, you simply apply the lacquer to the portion of any part you do not want plated and plate the entire part normally.

When the plating process is done, take some lacquer solvent and wipe it on to the area lacquered prior to plating—the lacquer and any build up of plating comes right off. It's a good system for keeping the trigger pull "just the way you had it." This method can save you considerable time when plating any type of firearm part.

STRIPPING

Stripping is used to remove old plating, to brighten up oxidized surfaces, and to clean inaccessible places. In general, there are four ways to take nickel plating off a gun. First, the finish may be removed electrically: the object to be stripped becomes the anode, and a piece of metal such as brass or stainless steel is used as a cathode. Second, you can polish it off in much the same way as you would polish off old blue on firearms.

Pure nitric acid will also strip nickel from iron or steel without attacking the base metal as long as it is pure. However, conditions such as humidity change the purity of the acid, and then it can literally dissolve a gun in a few minutes. Nitric acid is also very dangerous to handle.

The fourth stripping system uses chemicals for the process. It is a companion system to the electroless nickel plating system offered by Brownells. It will not pit or etch steel. It has excellent stability and a long, active solution life. Because of an easy replenishment system, solution life can be further extended, and this cuts the operating costs. The components contain no cyanide, so they can be shipped easily via UPS. The solution operates at a slower rate of stripping than most other systems that give complete control, and it will remove most nickel plating on firearms.

To strip, the gun should be disassembled and a heavy emphasis should be placed on cleaning.

This thorough cleaning prior to the stripping sequence removes all dirt, gun oils, and so on. The cleaning must be thorough to allow the stripping operation to work efficiently. The stripping steps are as follows:

1. **Pre-clean.** Use trichloromethane on cotton swabs and brushes to remove as much foreign matter, powder residue, gun oils, etc., as possible. Do not use a petroleum-based cleaner such as gasoline, kerosene, mineral spirits, or gun cleaner; they will leave a residue on the part.

2. **Flowing Water.** Use the same tank as used for plating process. Submerge parts for ten seconds and agitate to float away loosened residue.

3. **Acid-Cleaning Tank.** Submerge parts for three seconds and agitate. This further cleans parts and removes foreign residue, especially oil.

4. **Flowing Water.** Submerge parts for five seconds to flush acid cleaner from surface of metal.

5. **Nickel-Stripping Tank.** Submerge parts in stripping tank until all nickel is removed from the bright steel base metals. The stripping solution must operate at 200°-210° F. Water lost by evaporation should be replaced during the stripping cycle in order to maintain the original volume of solution. Parts will have to be removed from the stripping tank to be checked thoroughly to see that they are completely clean of the nickel plating.

6. **Flowing Water.** Submerge parts for 2 minutes to flush away all of the stripping solution. Allow stripped parts to air dry normally, or use compressed air to speed dry. The gun can now be polished or put back through the plating cycle. If you are not going to polish or plate immediately, be sure to oil gun surfaces with water-displacing oil (a basic rust preventative that does not contain any of the exotic penetrants that could contaminate future bluing or plating of the gun).

BROWNELLS 1082 NICKEL PLATING STRIPPER

This section gives most of the information required in stripping, however for complete, detailed instructions refer to the Brownells product information sheet, www.brownells.com/userdocs/learn/Inst-109ElectrolessNickel.pdf.

Three tanks are required for the #1082 stripping operation — the acid cleaning tank, the stripping tank, and the hot cleaner tank. The acid cleaning tank and the stripping tank cannot be the same ones used in the plating sequence — they must be different to avoid crossover contamination. To avoid any problems, they should be marked "For Stripping Only", and preferably kept in a different storage area. Because similar chemicals and solutions are involved, the same, strict, personal safety precautions must be followed as specified in the plating section.

If a direct gas flame is used for the heat source, the Pyrex tank must be protected

Figure 2: A heavy-duty hot plate/stirrer is the ideal heat source for electroless plating operations. The heating element heats a container quickly and then maintains the heat throughout the operation.

from thermal shock. (Special instructions are included with each Pyrex tank and explain in detail how to make a "sand bath" to protect the tank and keep it from breaking.) If you anticipate much plating, however, it is recommended that you purchase an electric hot plate stirrer like the one shown in Figure 2. This unit provides a reliable source of constant, even heat, plus thoroughly controllable agitation. It is specially designed for chemically stripping gun parts as well as electroless nickel plating.

The purpose of the acid cleaning tank is to clean only, and the solution should consist of 50 percent hydrochloric acid and 50 percent pure (distilled) water. The tank must be covered when not in use, and must be marked "STRIPPING ONLY" to prevent any mix-up with the plating tanks. To mix one gallon of solution for the acid cleaning tank, measure 2 quarts (64 fluid oz.) of distilled water and pour into the tank. Measure 2 quarts (64 fluid oz.) of hydrochloric acid and pour very slowly into the water already in the tank. Remember, always add the acid to the water and not vice versa. *When mixing this solution, always wear goggles and rubber gloves.*

Mix 8 oz. by weight (approximately 1 cup by volume) of Brownells Dicro-Clean 909 per gallon of distilled water. Heat to 180° F. and stabilize temperature. Suspend parts in the cleaning bath for 10-15 minutes.

To mix one gallon stripping solution: (Do these steps exactly in the sequence given!) Wash the Stripping Tank with clean water to remove any residue or possible contaminants. Pre-measure 1 gallon of water in your tank, and make note of its depth on your dipstick — or in your dipstick log. Dump and dry the tank. Measure 90 fluid oz. of distilled water (hot or cold) and pour into the Stripping Tank. Start agitation and heating. Measure one half pound of 1082-R and, very slowly, add to the water in the tank, allowing the agitation to dissolve the powder. Measure 26 fluid oz. of Concentrate 1082 and, very slowly, add to the Stripping Tank. Add sufficient distilled water to bring the total solution volume up to one gallon as measured by the dipstick. Bring the solution up to the operating temperature of 170°-175° F. Higher temperatures shorten bath life. Check the thermometer several times to be sure the heat setting is holding the temperature constant.

The Stripping Solution is now ready to use. During use, the stripping solution will darken noticeably and, after 2 to 3 hours of use, it will become the color of deep mahogany or very strong tea. This is normal and does not seem to affect anything. Parts should be suspended on iron wire. Do not use any other kinds of wire. Once parts are submerged in the stripping solution, they should not be removed

until stripping is complete to avoid contamination, which will result in less than a perfect job.

Once the parts are submerged in the stripping solution, they should not be removed for any extended period of time to avoid contamination. However, the parts can be taken out of the tank for a very brief period of time for inspection (to see how the stripping is progressing) and returned directly back into the stripping tank. If absolutely necessary, it has been found that the parts could be removed with no apparent damage for longer periods of time, but they then have to be run through the Flowing Water Tank, the Acid Cleaning Tank, re-rinsed in the Flowing Water Tank and then put back in the Stripping Tank.

As water evaporates out of the stripping tank, it should be replaced. Use the dip stick method, or make a mark on the side of the Pyrex tank. Do not allow parts to stick above the solution level, as the fumes from the stripping solution cause very rapid rusting and pitting. This will not happen to parts that are left submerged. The rate of stripping will vary greatly depending upon the type and thickness of plate that is being removed along with other factors. Most will fully strip between 45 minutes and 1½ hours. If parts do not strip in 2 to 2½ hours, the solution is too weak and must be replenished. On some guns the nickel plate is deposited on top of a copper plate that was put on the metal first as an undercoat for the nickel. These pieces will strip slowly, and the solution will turn the copper dark in color. However, as the copper is stripped away, the dark surface will disappear and all the plating will be removed down to the bare steel surface. Agitation of the solution is important and is done at the same rate as for plating. If the solution is not agitated, stripping will be much slower because the stripping solution (remaining close to the metal) becomes saturated with removed nickel and slows down in removing more. Fresh solution must flow by the metal surfaces at all times to distribute the dissolved nickel throughout the full gallon of stripping solution. One gallon of fresh stripping solution will remove the nickel plating from about four Colt .45 semi-automatic pistols. After this, the solution normally must be replenished. To replenish the stripping solution, first make certain that no guns or parts are in the stripping tank. Then be sure the agitation system is working and the solution is being agitated thoroughly. Also, be sure the temperature is 170-175° Fahrenheit. Add 4 oz. by dry weight of 1082-R to the stripping solution. This replenishment will normally allow the stripping of approximately the same amount of nickel as did the original fresh solution. However, after four replenishments of the stripping solution with Concentrate 1082-R, the solution will become super-saturated with dissolved nickel and will fail to strip any more. Dump the solution, wash the tank thoroughly with clean water, and mix up a fresh batch. After stripping is completed, turn off the heat, leave the solution in the tank and allow both to cool to normal room temperature while still sitting on the source of heat. *If you take the Pyrex tank off the hot plate and set it on a cold bench or counter top, it is possible that the thermal shock will break the tank.* Once cooled, do not store the stripping solution in the stripping tank. Pour it into a clean brown plastic chemical jug. Be sure to mark the jug “STRIPPER” and “POISON.” Also, label that jug as to how

many times the solution has been replenished. To reuse, simply pour back into the thoroughly clean stripping tank, bring up to heat, with agitation, to the correct operating temperature and begin the cycle.

Stripping (Figure 3) is a slow process and of all the sequences involved with nickel plating, the most worrisome, for very shortly after you put the plated piece into the stripping solution the piece turns a dark gray color and gets worse, and more mottled. Working as slowly as it does, it won't pit or etch the steel. And, you may not have to do even much more than touch-up polishing if you are stripping and replating a piece that is in good shape.

PLATING OPERATION

Twelve steps are required to plate a gun properly. These are outlined below and in the flow chart shown in Figure 4. Do not take any short cuts. Do each in turn, as given, for the time specified. Then go on to the next step. Layout of the plating room is completely optional, but do try to set up your tanks so a logical progression from tank to tank can be followed easily.

1. **Polishing**. Polish and prepare the metal exactly as for bluing. As in bluing a firearm, plating will not hide or fill scratches or pitting. A high gloss nickel finish requires metal preparation equal to "master-grade" bluing preparation, which means polishing right on down to No. 555-grit. A satin nickel finish can be achieved by using glass beading (very fine sandblasting), or a coarse wire scratch wheel with light pressure on the gun.

2. **Pre-Clean.** While this step is not an absolute must, it is highly recommended for best plating results. Use a degreaser and saturated cotton swabs to thoroughly clean all surfaces, including holes, crevices, and the like. This removes any old grease and accumulated dirt, silicone oils, other gun oils, and polishing residue — especially residue left by wax or grease-based polishing compounds. Do not use petroleum-based solutions like gasoline, kerosene, mineral spirits, or gun cleaner. If at all possible, thoroughly blow all parts clean with a medium to

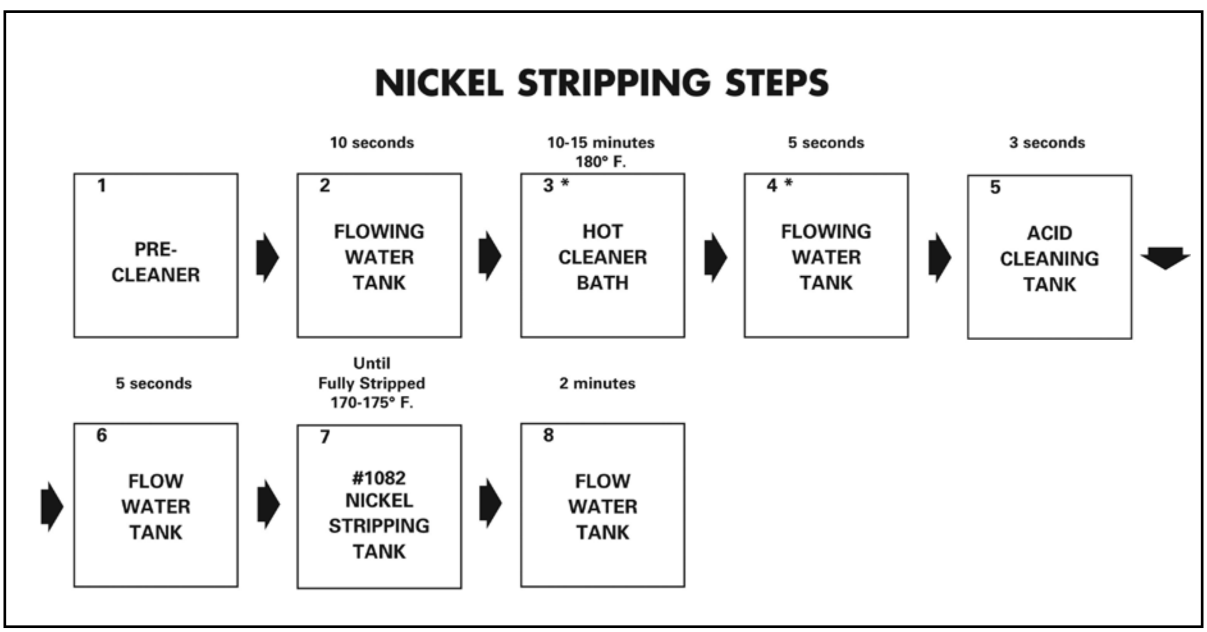

Figure 3: Flow chart of stripping operation.

high pressure air gun to help clean off loosened gunk.

3. **Flowing-Water Tank.** Submerge parts in the flowing-water tank for about 10 seconds to help float away any particles of foreign matter loosened by the pre-clean step.

4. **Pickling Tank.** Submerge the parts in a solution of 10 percent nitric acid for 3 seconds. The parts will start to "gas" (similar to Alka Seltzer tablets). This further removes any foreign contamination.

5. **Flowing-Water Tank.** Submerge parts in the tank for 3 seconds and agitate to flush pickling solution from the surface of the metal. This step is extremely important.

6. **Hot Cleaner Bath.** Submerge parts in the tank for 10 to 15 minutes with an operating temperature at 180°F. Agitate occasionally to ensure good surface cleaning.

7. **Flowing-Water Tank.** Submerge for 5 seconds and agitate to flush cleaning solution from the surface of the metal.

8. **Pickling Tank.** Submerge for 5 seconds to activate the surface of metal for plating. Parts will start to gas, indicating that the surface is activated. This step, in addition to cleaning, will make the nickel "strike" the metal surface, quickly assuring a good initial bonding to the surface.

9. **Flowing-Water Tank.** Submerge for 3 seconds and agitate to flush pickling solution from surface of metal.

10. **Nickel Plate Tank.** First determine thickness of the plate you wish to apply. For optimum results, $^{3}/_{8}$ in. mil (1 mil = .001 in.) plating depth is considered to be the best for guns. This thickness will require 45 minutes of submersion in the plating solution. Start the agitation system and submerge the parts to be plated into the plating solution. (Make sure they do not touch each other or the

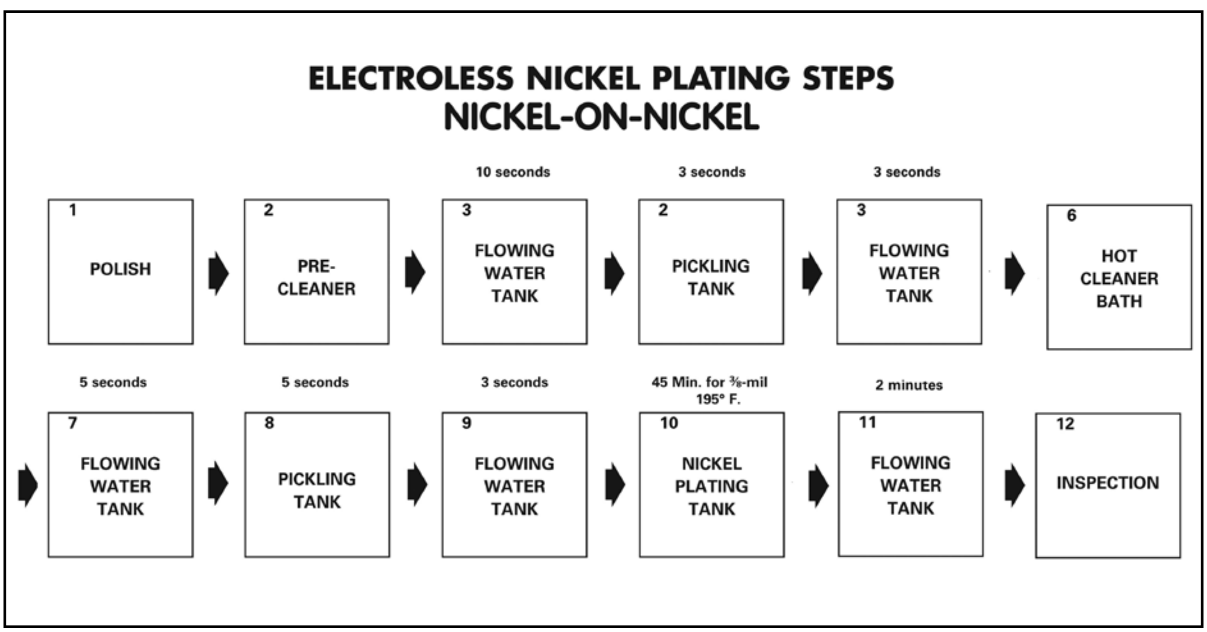

Figure 4: Electroless nickel plating steps.

sides of the tank.) Be sure that agitation is thorough, and that whirlpooling does not develop. The solution must operate between 190°-195°F optimum.
Once the pieces are in the plating solution, do not remove them until the desired length of time has elapsed. If you do, even for an instant, you will ruin the plating job and have to start over. When the predetermined time has elapsed to plate the thickness desired, remove the parts from the plating solution.

11. **Flowing-Water Tank**. Submerge the parts for a minimum of 2 minutes and agitate to flush the nickel solution from the metal surface. There is no maximum time limit in this tank as the nickel plating process has been completed. Remove the parts from tank and allow them to dry naturally or use compressed air for faster drying.

12. **Inspection.** Check all parts and components carefully to assure an even plate of all desired surfaces prior to assembly of the gun. However, if a part or component is not nickel plated as desired, it cannot be put back into the nickel tank. The part must be stripped of all nickel and reprocessed from bare metal! If all parts and components are satisfactory, wipe all parts clean and dry with a soft cloth to remove water spotting or lingering wet areas in holes, etc. If a high-gloss finish is desired, you can buff the parts lightly on a loose muslin wheel to bring up the luster, or use a professional nickel-finish polishing cloth. If the buffing wheel is used, use only No. 555 White Polish-O-Ray and very light pressure, as any form of polishing will remove metal, and you will be removing the nickel plate you just put on. Semi-chrome polish can also be used to

Figure 5: Nickel Plated Colt Mk IV Series 80 M1911A1.

increase the luster of a high gloss finish. Reassembly of the gun is the final step.

The complete plating procedure consists of two phases, both equally important. First, is a preparation of the metal to enter the plating solution and second, the actual plating of the metal. Any attempt at short cuts in the procedure usually results in a poor plating job, and wasted time and material. At first, the process will seem lengthy, especially the cleaning steps prior to putting the piece into the plating tank. However, with a little practice you can complete the plating process in about the same amount of time required for a good bluing.

The preparation phase is a step-by-step sequence in getting the metal absolutely clean of all foreign residue down to the bare metal. When metal is stripped of all protective coating, it absorbs oxygen and oxidizes very quickly in the open air. Oxidation on the metal surface prevents good initial bonding of nickel to metal. Therefore, the time between each step should be as short as possible. Work quickly but at a steady pace between each step. Timing in the tanks, in seconds, does not require a stop watch. If you say the words, "One thousand and one" it takes about one second. Hence "one thousand and one, one thousand and two, one thousand and three," will take three seconds. Try it— it works!

Equally important is the flushing step between each tank. It prevents the carrying or "drag out" of chemicals from one tank to another tank, which would result in chemical contamination of the second tank.

If you can blue guns, you can plate guns. It is only a matter of familiarization and practical experience. The major difference is that plating requires extreme measures to assure parts are clean prior to entering the plating solution. As with all types of metal finishes, it is best to make a test run by using scrap parts until you become familiar with the process instead of making the first plating job on a new gun. According to Brownells, the most common cause of poor plating jobs can be directly traced to lack of cleaning or contamination of solutions. Also see the troubleshooting chart in Figure 7.

It is possible to plate one or two parts for 2 hours and give them a one-mil plate build-up if desired. This can occasionally be done to tighten up loose fitting screws, pins, and other slightly worn parts. Plating past this one-mil thickness is not practical. And, be sure to remember that every surface will receive the same amount of plate and increase by the same thickness. So, while you may tighten up threads of a screw, you may also keep the head from fitting flush, or fitting the counterbore at all.

Agitation of the plating solution is critical, because too great an agitation will result in whirlpooling, which draws air into the plating solution. This extra air will "crater" the nickel plating being put on the metal surface and you will have to strip the piece and start over because the poor plating cannot be saved. Too little agitation will result in "pebbling" of the plated surface (little humps and random bumps). This is more easily remedied, for the part need only be polished

Figure 6: Millions of break-top revolvers were manufactured in the Unites States around the turn of this century. Many of them were nickel plated and the gunsmith will be called upon to restore the plating on these handguns.

TROUBLESHOOTING CHART			
MALFUNCTION		**MALFUNCTION**	
Probable Cause	**Remedy**	**Probable Cause**	**Remedy**
NEW BATH DOES NOT PLATE		**"CRATERED" SURFACE**	
1. Improper make-up	Bring bath into specs if can determine mistake. If not, discard bath.	Plating solution agitation too fast.	Slow down agitator with speed control. Part must be stripped and replated. Will not polish out.
2. Incorrect bath volume	Adjust bath if can do so correctly. If not, discard.		
3. Temperature too low.	Check thermometer; heat source. Must operate between 190°-200°F with 195°F optimum.		
POOR SURFACE ACTIVATION		**"SANDY" SURFACE**	
1. Acid too old or too weak.	If so, remake.	Took part out of plating bath and put back in during plating cycle.	Do not remove parts once put into plating tank. You will get a "false plate," which must be stripped and replated if careful polishing does not remove.
2. Oil contamination in tanks.	Find source. clean up, then remake all baths.		
3. Poor rinsing between cleaning steps	Increase agitation or water flow.		
4. No nickel strike on stainless steel or hardened steels.	See special note on "Wood's Nickel Strike" to activate surface.		
"SMUT" FORMS ON SURFACE AFTER PICKLING		**DISCOLORATION ON SURFACE**	
Result of over-activation by pickling solution.	Wipe off parts with cloth and repickle for shorter time and/or reduced strength of pickling solution.	1. Shaded "grey" streaks caused by parts touching, hanging loops tight, too large a part in too small a tank.	Use large tank; run more than one batch. Use "O" shaped hanging loops.
		2. Adding water during part time is in plating tank.	Water top-off volume can be done only when no parts are in plating tank; then temperature must be restabilized to 195° F.
		SMEARS, STREAKING	
		Surface not clean.	Remember, clean - clean - clean and clean again. Strip and replate.
PEEBLY SURFACE			
Plating solution agitation too slow.	Increase speed to just before cavitation or whirlpooling starts. Surface can be cleaned up with 555 White polish on loose muslin wheel and very light pressure		

Figure 7: Electroless plating troubleshooting chart. *(Continued on next page)*

MALFUNCTION		MALFUNCTION	
Probable Cause	**Remedy**	**Probable Cause**	**Remedy**
CONTAMINATIONS		**PLATING CAME OFF**	
1. Check for galvanized aluminum, copper, or brass in tanks, racks, hanging wires, or stir rods, leaded steel, heavily soldered or Check for Brazed parts.	Discard contaminating metals & make baths.	1. Surface not clean	Strip, reclean and plate
2. Residual acid left from stripping.	Generally will have to discard bath.	2. Tried to plate stainless steel or hardened steels.	See special note on "Wood's Nickel Strike" to activate surface.
3. Containers, mixing cups, stir rods, etc. mixed between plate bath, and cleaning bath.	Generally have to discard solutions. Always use separate mixing/measuring cups and label for which bath used.	3. You took it out of the plating bath to look at it and put it back in for some more plating.	You cannot do this for it will "false plate" and may come off. Strip and replate.
RAPID DEPLETION OF A-1, B-1, 778		**PLATING TOO THIN**	
Poor chemical reaction, result of storage below 50° F.	Return to solutions as described below. Ideal storage is 60°-90° Fahrenheit.	1. Tried plate with depleted solution.	Check mil-usage record on storage jug. Make new solution then strip and replate.
		2. Check surface area-to-volume of plating bath ratio. One gallon does only 114 sq. in. 1/2-mil thick.	May require larger container and more solution volume.
WORKING LIFE DEPLETES TOO SOON		**PLATING TOO THICK**	
Plating solutions stored in tanks, open containers, and not light-proof containers.	MUST ALWAYS be kept in dark brown chemical jugs when not actually in use to preserve working life.	Too long in plating bath.	May require in plating bath. One hour gives 1/2-mil; 45 minutes gives 3/8-mil; 1/2 hour gives 1/4-mil. Generally thick plating can be polished off with 555 White polish on loose muslin fit often. Be sure not to cut through plating.
SURFACE ROUGH WITH SCRATCHES		**CASE HARDENED/CAST STEEL PLATES UNEVENLY**	
Probably not polished to fine enough grit before plating.	Plating will not hide anything!	1. Many case-hardened surfaces do not activate as well as unhardened steels	Leave in pickle longer than normal until good gassing occurs.
		2. High silicone content of some cast steels may inhibit plating	Pre-clean to the point of "overkill" with Trichloroethane to remove silicone
		3. Cast parts will usually not polish well enough for "Bright nickel plating".	Suggest sendblasting cast surface before plating for a deluxe "satine" nickel finish.

Figure 7: (Continued)

carefully with 555 White Polish-O-Ray on a loose muslin wheel to remove the "pebbles."

Sandblasting of parts prior to plating is one of the most universally appealing finishes you can give your guns. Especially consider decorative use of sandblasting. For instance, sandblast the entire cylinder, then polish just the outside back up to bright, leaving the flutes sandblasted. Once plated, the contrast between bright and satin is very handsome.

Polishing prior to plating is more important than you can realize as you read this lesson. Every scratch, rough spot, or nick is highlighted by the plating; absolutely nothing is hidden, not even those things bluing will sometimes hide. So, consider the satin finish if you do not want to go to the trouble of doing the high degree of polishing required for a mirror-bright finish. Many shooters prefer the satin finish anyway.

Do not mix and add more fresh plating solution to a partially used batch. This is a tempting idea but do not do it, for you then lose track of the plating capacity of the total solution.

Because of the acids used, parts not directly under the surface of the plating bath will rust badly — worse than in the bluing room. The small amount of water that condenses on hanger rods and falls back into the plating bath is of no consequence. But do take precautions by keeping all easily rustable equipment and items out of the plating room.

If you are working on a rusty gun that you want to put through a rust or bluing remover solution, you must do so before you polish the gun. Most removers contain phosphoric acid, which acts as a "pacifier" to steel, and will prevent it from plating. Polishing will remove this pacified surface, so you must polish thoroughly and completely. Then the precleaning, pickling, and cleaning steps in the plating sequence should properly "activate" the steel surface. If you notice that the part does not gas in the pickling tank immediately, you may have to leave it in for a few more seconds to be sure that the surface is sufficiently activated for the nickel plating to "strike" the surface and adhere correctly.

The troubleshooting chart shown in Figure 7 will help you to correct problems that may arise when using Brownells Electroless Plating Method. When the chart advises to "strip and plate," it does not mean to run the part through the stripper and then directly back into the plating tank. It means to take the part through the stripping sequence, then through the entire 12 steps of the plating sequence! If you skip a step and put a dirty part back into the plating tank, it will not plate correctly. You cannot skip any step of any sequence.

Parkerizing

Parkerizing, or phosphate coatings, provides an excellent surface for holding a rust-inhibiting or lubricating compound. Oil is absorbed in the finish, and has the effect of a lubricant reservoir, which helps in the break-in of friction-bearing surfaces. Whereas, untreated surfaces of steel are prone to rust, phosphate coatings are much more resistant to the elements, making this type of finish ideal for military rifles like the one shown in Figure 8. Phosphating solutions consist of zinc, manganese, or iron dissolved in carefully balanced solutions of phosphoric acid. When iron or a reactive metal is placed in the phosphating solution, a light acid etching takes place.

Shortly thereafter, depending on the accelerators used, a very small amount of metal is removed from the surface, and a hydrogen process takes place, which in turn precipitates a phosphate coating on the steel, which is bonded to the metal. Once applied, the coating can act to resist corrosion, as well as to improve wear resistance.

The length of time the part is immersed and temperature of the solution can be critical, depending on the amount of solution used, as well as the type of the metal being treated. Zinc phosphate treatments will generally produce a deposit of zinc phosphate compound on the base metal. These normally have a coating range between 0.0005 in. and 0.0015 in. in thickness, and vary in density. The density and coating thickness are not reliable indicators of the corrosion-inhibiting qualities of the finished product. The appearance of the zinc phosphate coating is a gray matte finish, with the shade varying somewhat, depending on the chemical composition of the treatment bath, and the amount of ferrous or iron based material in the metal. The zinc phosphate coating itself has an outstanding corrosion resistance, due to the fact it provides a waterproof barrier. It is best not to deviate from the manufacturer's directions, as complications can arise.

SAFETY

Most Parkerizing solutions have been professionally formulated and manufactured in compliance with all applicable safety standards. Information and recommendations concerning their use are based upon laboratory tests and field use experience. However, since conditions of actual use are beyond the control of the

Figure 8: The M1 Grarand rifle was the "best" there was for combat used in World War II and the Korean War. Many owners now want these fine rifles restored to their original condition; this means Parkerizing the metal. Knowing how to correctly Parkerize gun metal can mean extra profits for your business.

manufacturers, any recommendations or suggestions are made without warranty. It is the user's responsibility to see that the procedures are meticulously followed, and especially that the warning and cautionary notes are heeded. **READ THE WARNING INFORMATION ON THE CONTAINER.**

Make sure the shop is properly ventilated, and leave a window open for fresh air. Do not use or store chemicals near food or in a food preparation area. Wear rubber gloves, a full face shield, and a neoprene apron. Train your eyes to see an accident before it happens!

EQUIPMENT

Besides the Parkerizing solution, you will need a stainless steel tank large enough to accommodate the parts, a thermometer that will measure up to 180° F, a measuring cup (graduated in ounces), a pair of tongs with at least 8 in. handles, degreasing solution, applicators, sandblasting equipment, a source of heat, and a means of securing the parts in the solution.

Stainless Steel Tank. For most projects, a tank 6 in. x 6 in. x 40 in. long will suffice. You can obtain less steel in sheets and do the welding yourself or have it done at a local welding shop. The stainless steel sheets, however, should not be less than 22-gauge. Pre-made stainless steel tanks are also available.

An optional method is to obtain a piece of threaded stainless steel pipe about 6 in. in diameter and 4 ft. long. Screw a 6 in. stainless steel cap tightly on the bottom end and rig it as shown in Figure 9. An asbestos-lined sheet metal housing will help to conserve heat. Because the tank is in a vertical position, it will take up less floor space than conventional horizontal tanks, and since the solution is heated at the bottom of the vertical tank, the heat will rise and circulate to maintain an even temperature throughout. The only problem is if a small part should fall to the bottom of the tank, the entire tank usually will have to be dumped to retrieve it.

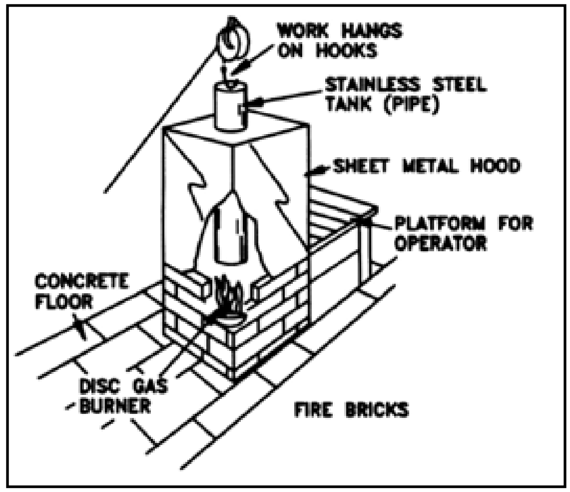

Figure 9: Vertical stainless steel tank system for Parkerizing.

Another drawback with the vertical setup is dumping the solution once it is spent. The entire tank must be pulled out of its housing and then dumped in a safe place. You could weld a stainless steel gate valve into the bottom side of the tank, but this will add to the expense. Another way is to weld a ring or hook at the top of the tank where another hook on a cable can be attached. This cable fed through a pulley above the tank will enable you to lift the tank, filled with solution, and keep it suspended until you can dump it. If a drain is nearby, fabricate the sheet metal hood so that one side opens as well as the top. Then you can dump the chemicals, as you gradually lay the tank over to one side. Remember, a 6 in. tank filled with Parkerizing solution is not going to be light.

Heat Source. Your local gas company (natural or LP) can advise and supply you with a simple pipe burner for horizontal tanks; use a ring-type industrial gas burner for the vertical tank. For the vertical setup, mount the burner close to the floor, but above a layer of firebricks for protection and insulation. Mount the tank so that the bottom is about 4 in. above the burner, with the

tank enclosed in heavy sheet metal and lined with some type of furnace insulation to conserve the heat. Firebrick should be installed all around the burner up to the bottom of the tank to where the hood stops. Of course, you need to leave an opening in the firebrick for lighting the burner.

Although it is not necessary, you might want to fabricate a loose fitting sheet metal cap to fit over the top of the tank to conserve heat and energy. If so, it should be slotted in the center so that it will slide freely on the suspension wires on which the work is hung for lowering into the Parkerizing solution. With a 6 in. pipe, as many as four barrels and receivers can be Parkerized simultaneously. It is desirable to finish as many as possible at one time due to the length of time required to complete this process.

Small parts can be grouped on small hooks of stainless steel wire, or you might want to make a basket out of stainless steel screen wire. However, in doing so, the parts should be shaken frequently during the process to avoid constant contact, which might leave spots on the finished work.

Sandblasting. Rust or scale on the gun parts must be removed before putting them into the Parkerizing solution. The best way to do this is by dry abrasive blasting using glass beads. Silica sand may be obtained from your local lumber yard (where it is sold for mixing white plaster), or obtain glass beads from a local auto body repair supplier. The sandblasting equipment is not cheap, and it is going to take a number of Parkerizing jobs to pay for the equipment. So until you have enough business to warrant such an outfit, it will probably be better to "farm out" the sandblasting operation to a local auto body shop. Most shops will be glad to do the operation for a reasonable fee. In any event, glass-bead all parts until a chrome look is obtained and no dark spots remain.

Figure 10: Since sandblasting equipment is expensive, you may wish to send out your gun parts for sandblasting.

After the abrasive blasting, do not handle any of the parts with bare hands. This will leave body oil on the parts and cause spotting. Always use rubber gloves for handling the parts just as recommended for most bluing jobs. Get the parts into the Parkerizing solution as quickly as possible after the abrasive treatment. Never wait more than 3 hours.

Treating. There are several suppliers of Parkerizing solution and all will vary slightly, so follow instructions provided by each. One type requires that you prepare enough solution to cover all parts sufficiently at a concentration of 4 oz. of Parkerizing solution per gallon of water (3 percent by volume). Mix the solution in a stainless steel tank, light the burner, and bring this solution to a temperature of between 160°F and 170° F. The parts are then suspended in the solution by wires or hooks. The parts should not be touched with bare hands. Once the parts are suspended in the Parkerizing solution, allow the metal to react. Turn the parts periodically to get an even treatment, but be careful not to agitate the parts where they will rub or grind against each other.

As in hot caustic bluing, temperature is of the utmost importance at this time. Be sure to maintain a temperature of 160°-170°F. Nothing else will do! But remember: this temperature will vary with each manufacturer.

The parts should be left in the solution for about 40 minutes and then removed and immediately rinsed in cool running water for one minute. Drain excess water and dry with a clean absorbent cloth. Once the parts have dried, immediately dip them in a light oil bath or spray the parts with WD-40 or some similar oil. Wipe off all excess oil and the job is completed for a gray-type finish. Repeated applications of Cosmoline in place of the oil bath will usually provide a green tint to the finish.

As long as the bath is hot and the solution is clear, the bath can be used to Parkerize any number of guns. A cloudy solution indicates depletion of its active ingredients. Also, once the solution has cooled, do not attempt to reheat and use it. Dump the solution in a safe place once it has cooled. Check with your local health department about getting rid of any chemicals listed on the label of the container. *As with any chemicals, wear safety goggles or a face shield and avoid contact of the solution with skin.*

For information on Brownells' Manganese and Zinc Parkerizing products, you can read their product information here: www.brownells.com/userdocs/learn/Inst-482%20Parkerizing.pdf

Figure 11: The .30 caliber M1 carbine is another rifle used during World War II and the Korean War that was Parkerized.

Figure 12: This Perrin Army Revolver could use some restoring.

Restoring Metal Finishes

Restoring the metal finish on antique or obsolete guns is a controversial subject, especially among collectors. Many valuable firearms have been completely ruined by hobbyists who were not aware of the gun's value and tried to "fix it up." A good rule of thumb for restoring antique firearms is to try to stop deterioration, preserve the current appearance, and, if possible, not rework any parts. Restoring modern firearms can also be a mistake. For example, many firearms manufactured before 1964 have recently gained some collector value. If 80 percent of the original finish is present on any of these guns, they should be restored only to the extent of avoiding further deterioration.

On the other hand, there are models that are definitely in the collectors' class, but have been seriously neglected through the years. Perhaps the wood has been cracked or gouged, certain parts have rusted badly, and pits have formed in the metal. Such a gun will normally have little collector value, unless it is a rarity. If the gun can be restored to a good appearance and working order, restoration is certainly legitimate and should be encouraged.

The main objective in restoring an old firearm is to maintain the gun's original form. For example, if the metal finish is to be restored, the original finishing process should be implemented, if it is known. If the original finishing process is not known, one of the processes of the period in which the firearm was originally produced should be applied. The original process of assembly should be applied to all parts of the gun. For wood, any missing parts should be replaced

with original parts, if available. If not available, try to obtain reproduction parts that are as authentic as possible.

The main objective of this lesson is to discuss some of the metal finishes that are used on antique and obsolete firearms, and when and how to restore these finishes.

EVALUATING FIREARMS

Firearms are brought to gun shops in various conditions. It is up to the gunsmith to assess its condition and find out what the customer wants to do with the firearm once restored. An owner might want to put a badly abused gun back into service. Other firearms might have a sentimental value to the owner who wants the gun restored. Some owners who are collectors might want to restore a gun for a collection. However, in all cases of gun restoration, the gun should be in poor condition before restoration is attempted.

The first step is to inspect the entire gun carefully with a magnifying lens, making notes during the process. Look for hairline cracks in the metal and wood parts. Note any rust and any pits, both inside and out, without disassembling the firearm. Check the action for proper functioning using blank ammo or snap caps for testing.

After evaluating the gun's exact condition, clean it thoroughly from muzzle to butt. Try to remove all foreign matter, but not the original finish. During cleaning, more defects will probably surface.

If the gun functions well, it is usually best that you not restore it. On the other hand, if the gun is not functional in its present condition, and if it is not a rare firearm, further restoration might be called for.

The extent of restoration can range from replacing a small, defective part to overhauling the gun completely, removing all pits, rejuvenating engraving, rebluing, and replacing or refinishing the stock and fore-end. It depends entirely on the value of the firearm and what the customer wants. Keep in mind that usually a collectible firearm, like the one shown in Figure 13, will lose some value (unless it is in very poor condition) when it is restored. This is why most restored guns are working guns, rather than collector or valuable firearms.

Figure 13: This Remington Beals Army Percussion revolver is a rare find, especially in good condition. No attempt whatsoever should be made to restore such firearms beyond stopping any further deterioration.

RESTORATION TECHNIQUES

In general, modern gunsmithing methods cannot be used on old gun parts, like the one shown in Figure 14, because the results are usually unsatisfactory. For example, power metal polishing cuts too much metal and closes the pores in the metal. As a result, the fine blue-black finish does not appear. The popular hot caustic bluing method is another forbidden practice on most antique firearms. The glossy black appearance of this finish does not look authentic on the older guns.

The hot caustic method also attacks soft soldering, the type used to secure barrel ribs and to join the barrels on the older double-barrel shotguns.

There are several alternative methods to restore old guns. For example, a gunsmith can use a power buffer to remove some pits in the metal and then polish by hand. The slow rust method or the hot water method can be used for restoring many high-quality guns instead of the hot caustic method. It is important to discover methods that are less harsh on the old firearm, and yet can restore the gun to a greater value.

A technique that adds to the value and authenticity of many older firearms is color case-hardening. Color case-hardening involves hardening metals that result in hues of mottled blues, browns, grays, and blacks. Few gun shops offer this service, mainly because most formulas require the addition of cyanide to the hardening compound, which is lethal. Color case-hardening can be performed without the use of cyanide but the process takes longer.

One of the most difficult items to restore on a firearm is the engraving. The majority of fine metal engravers had their own style and technique, and you can well imagine the difficulty a good modern-day engraver experiences duplicating the work. Fortunately, most gun engravings do not have to be completely re-etched. Many times, the engravings only need to have lines deepened. For example, the trigger guards on some double-barreled shotguns have a simple border engraving on them. These same trigger guards are subject to rust and pits and, in many cases, removing the pits means removing the engraving, too. An expert restorer makes an exact pattern of the original border engraving and also takes close-up photos before any polishing begins. The pits are removed, taking off as little metal as possible. The restorer or the engraver recuts the engraved border following the original pattern prior to bluing, which maintains the original appearance of the firearm.

Figure 14: Restoring the finish on the receiver of this W.W. Greener double-barrel shotgun calls for intricate and timely work.

Obviously, a firearm restorer must be a highly dedicated individual, know firearm history, and know the techniques of the period and how to apply them. Mostly, a restorer must have an appreciation of high craftsmanship.

CUSTOMIZING

Occasionally, it is best to customize an old rifle, rather than restore it. For example, let's assume that a customer takes to a restorer a pre-64 Winchester Model 70 with a shot-out barrel, a broken stock, and a badly scratched receiver. An original barrel and stock for this model, if available, will run over $500. Add the labor involved in replacing and refinishing these parts, the final sum would be approximately $1,500. And unfortunately, after all of the restoration work, the customer will not have an original Model 70.

A good Model 70 can be purchased, at this writing, for about $1,000, but can go as high as $3,000. Why bother restoring it? A customer would be better off trading it in or selling the action to a gunsmith to be made into a custom rifle, then buying a good used Model 70 from a dealer.

On the other hand, a customer might want a custom-built rifle. A competent gunsmith needs to be able to assess what the customer wants as well as what is the most practical solution. Sometimes, it might be better to customize rather than restore. Again, it depends upon the rarity of the gun in question, what the customer wants, the time involved in restoration, and the expense.

You will probably want to do some work yourself and then "farm out" any parts of the restoration that you would prefer not to handle. However, be sure to check the restorer's credentials thoroughly. If there is any doubt as to whether or not you should have a particular gun restored, wait until you are absolutely sure you want the work done.

When deciding to restore a firearm, first consider the function of the gun. The firearm should first be repaired to function safely and properly.

The wood of a particular firearm should be the next consideration. A careful examination will reveal if the stock should be replaced entirely or if it only needs to be repaired and refinished. If repairing or restoring the gun, any existing checkering should be cleaned out first, the area masked off, and the remaining surfaces sanded or the finish chemically removed.

Figure 15: The metal used in the Colt percussion revolver is much different than the modern steel used in the Colt Python in Figure 16. In fact, the steel in Colt revolvers has changed hundreds of times of the past century.

METALS USED IN FIREARM PRODUCTION

Metals used in the production of firearms consist of iron, steel, copper, bronze, brass, aluminum, and nickel alloys. The materials for the metal are selected based on tensile strength and hardness.

The metal specifications regarding the properties of tensile strength and hardness are often furnished by the raw material supplier. For example, specifications are available for steel that is suitable for case-hardening, stainless steels that resist corrosion, brass suitable for screw machine work, or for drawing operations, and so forth.

Restricting Impurities. The specifications of the metals might restrict the content of elements considered to be impurities, such as phosphorus and sulphur in iron. These restrictions specify the carbon content of iron and steel, and indicate the content of nickel, chromium, or copper in the various alloy irons and steels; the copper, tin, zinc, and nickel content of bronzes; and the silicon and copper content of aluminum. There are, of course, general rules and specifications for any material used.

Choosing Material. The material from which a gun part is made must be carefully selected based on the function of the part. A steel casting, for example, might be used for a part because it is tougher than cast iron and can stand shock better. Aluminum castings are sometimes used for trigger guards, for frames in low-pressure, rimfire rifles, and other areas where lightness, strength, and resistance to corrosion are important. The Colt revolvers shown in Figure 15 and Figure 16 use different types of steel.

Among the principal specifications of any material are the tensile strength and the hardness.

Tensile Strength. Tensile strength is the maximum amount of the stress that the material can withstand without breaking. It is usually measured in pounds per square inch (PSI). While most cast metals fracture easily when tested for tensile strength, wrought materials, especially steel, stretch before breaking.

Figure 16: The steel in the cylinder of this Colt Python revolver is of a special high-tensile strength to withstand the 40,000 psi pressure of the .357 Magnum cartridges. The use of a lesser strength material would surely result in a ruptured cylinder.

Hardness. Hardness is the material's resistance to scratches, cuts, and dents by other materials.

Metals can be given fairly definite values of tensile strength and hardness by alloying, by heat treatment, or by both. The nature of the necessary heat treatment that increases any particular property usually forms part of the specification.

Alloys. An alloy consists of two or more metals mixed together by melting, usually with a larger proportion of one metal to the other metals. Steel can be alloyed with nickel, manganese, chromium, tungsten, molybdenum, vanadium, or cobalt. Copper can be alloyed with zinc to form brass or with tin to make bronze. Aluminum and a small amount of copper makes duraluminum, which has the strength of steel but the lightness of aluminum. Small amounts of other metals added to cast iron give the alloy valuable properties.

Most moving gun parts are made of steel because of its high strength, which in the case of certain alloy steels may reach 200,000 psi. Also, most steels can be machined by average equipment in the annealed or normalized condition, and then hardened by various methods. Some moving parts in firearms, such as a breechblock, have a high stress when working because of the pressures developed when a cartridge is fired. These are almost always made of alloy steel.

Carbon and manganese were the chief alloys used in gun metal during the early part of this century. However, too much of either made the steel too brittle. Nickel was used to toughen steel. Adding chromium to steel increases its strength without much decrease in ductility. Chromium is one of the alloys used in stainless steel. Molybdenum increases the ability of steel to withstand shock and fatigue.

Steel. Cast steel is usually low in carbon compared to cast iron, sometimes as low as 0.10 percent carbon. Cast steel is always given at least one type of heat treatment. It can also be alloyed with chromium, nickel, vanadium, molybdenum, copper, or a combination of these elements, in addition to the manganese and silicon that are generally present.

After normalizing or annealing, hardening, and tempering, cast steel develops a tensile strength of at least 60,000 psi and with some alloys as high as 120,000 psi.

Steel is described in various terms, some of which relate to the process of manufacture and others to the carbon or alloy content. What is collectively referred to as mild steel is generally a cheap material used for structural work and general purposes. Sometimes it is designated as *Bessemer steel* because it can be made by burning out the carbon from the pig iron in a Bessemer converter.

Open-hearth steel is made in a furnace by a boiling process. Unlike Bessemer steel, which is always made from molten pig iron, open-hearth steel can be made from steel scrap as well as pig iron. Both these processes produce steel from iron by removing carbon.

Crucible steel, which is sometimes called cast steel, was the most common type for producing tool steels and other high quality steels for many years. Today these steels are almost always produced in electric furnaces. The crucible method consists of placing the iron, carbon, and other alloys in specific proportions in a small pot or crucible, which is heated as a unit in a large, flat, gas-fired furnace. When melted, the hot crucible is lifted, the seal broken, and the molten metal poured into ingot molds. Each crucible usually holds about 100 lb. of steel.

Steel Drill Rod. Drill rods come in various lengths, but 36 in. is the most common length. Drill rods range in size from #1 to #80 in drill-gauge dimensions. They are also made in letter and fractional sizes, in squares, and in flats. Drill rods are always useful for making drift pins, screws, screwdriver tips, firing pins, cleaning rods, and many other necessities.

Spring Steel. Spring stock is available in several types and sizes, including coils, spring wire, round oil-tempered spring stock, and flat spring stock. All of these are available from Brownells, Inc., as well as other manufacturers.

Steel Tubing. Steel tubing is available in all required weights and diameters and has many uses. Barrel bands, magazine tubes, and bushings can easily be made from steel tubing. A special tubing is also used for the oil tubes of barrel drills, barrel reamers and rifling heads. Another type of tubing is used for relining rifle barrels.

Furnaces. The basic electric furnace is constructed in sizes that are able to produce 1,100 tons at each heat. In a typical furnace with a cold charge of scrap and alloying materials, all of the known chemical and physical properties are melted by passing heavy currents of electricity through the steel. When melted, burned lime and fluorspar or sand is added, which forms a basic slag in combination with the oxides from the molten metal. Chemical analysis is made several times during melting to check the elements. The entire furnace is tilted to pour the molten metal into a ladle then into ingot molds.

Tool Steels. Tool steels are produced in a wide variety under many trade names. They can be classified into a few general types of steel.

The most common and oldest type of steel is *carbon* or *water-hardening tool steel*. It usually hardens into a very hard outside or chill case with a comparatively tough and softer core, providing the strength necessary for high-impact jobs such as punches. It is also used for hand tools. Small additions of vanadium or chromium produce steels of similar general characteristics, but of a finer grain and a deeper hardening.

Low carbon and low alloyed tool steels are used for jobs requiring high strength and medium hardness such as dies for metal die castings, tough chisels, punches, etc.

Figure 17: Most hand tools used in gunsmithing work are made from tool steel.

Highly alloyed, high-carbon, high-chrome steels are used for very long-wearing operations. They are, in general, difficult to machine and grind.

High-speed steels are generally used as cutting tools, tool bits, drills, milling cutters, and so forth. They are characterized by their ability to maintain hardness and a sharp cutting edge even at dull red temperatures. Tungsten and molybdenum are required elements with chromium, vanadium, and cobalt. They are also used at times for hot working dyes and sometimes for regular cold working tools, dyes, and the like.

The majority of gunsmithing tools, like the ones shown in Figure 17, other than those made from alloy steels, are made from tool steel with a carbon content of 0.85-1.35 percent, according to the final hardness wanted.

These high-carbon steels, however, are not often used for machine parts. Softer steels are cheaper and easier to mold. The necessary hardness is

attained by causing the surface to absorb carbon in the case-hardening process.

The main difference in steels is the carbon content, and the percentage of nickel, chromium, vanadium, molybdenum, tungsten included, which gives definite strength and hardness values to the resulting mixture. The substance made from cast iron, by the Bessemer process, the open-hearth furnace, or in an electric furnace, is carbon-free iron. Certain amounts of carbon and other elements are added to this.

Grain of Steel. Grain size of steel is important to users. In most applications, the fine-grain steels are deeper hardening, tougher, less apt to develop quenching cracks, less susceptible to grinding cracks, have less distortion in hardening, and have lower internal stresses. This same material is more difficult to machine, but gives better machining in fine-cut finishes. The opposite is true of the coarse-grained steels, which have a grain size of less than five.

Alloying Elements in Steel. Aluminum is used as a deoxidizer. It is also present in steels made specially for nitriding.

Chromium increases the ability of a steel to harden, increases the abrasion resistance (especially in compositions with high carbon), and contributes to strength at high temperatures.

Cobalt resists softening at high temperatures and decreases the ability of steel to harden.

Manganese is required as a deoxidizer, offsets the harmful effects of sulphur, and produces a moderate increase in hardenability. At 12 percent, it produces a hard material. This material will not harden under regular, quenching heat treatment, but from cold working.

Molybdenum considerably increases hardenability, increases strength at high temperatures, and corrosion resistance in stainless steels. It also increases strength and can replace tungsten in high-speed steels.

Nickel promotes high toughness in composition with other elements and develops good hardenability. In stainless steels (combined with chromium), nickel produces good corrosion resistance and is not hardenable by quenching treatment, but by cold working. Very high nickel alloys have special thermal and magnetic properties.

Phosphorus improves machinability in high-sulphur steels, but must be limited to less than 0.05 percent to obtain plasticity. It contributes to hardenability, strengthens low-carbon steels, and adds some corrosion resistance.

Silicon is a general-purpose deoxidizer and increases strength, especially in combination with manganese. It is universally used in magnetic sheet steels to aid in crystallization and increase electrical resistance.

Titanium is a good deoxidizer, prevents grain growth at high temperatures in stainless steels, and reduces hardenability in medium-grade chromium steels.

Tungsten resists softening at high temperatures, increases hardenability, and forms hard, abrasive-resistant carbide particles. It is almost always present in high-speed cutting tools.

Vanadium produces fine-grain steel and increases hardenability.

Figure 18: Some gun parts, especially some rifle receivers and revolver frames, are case-hardened with mottled colors.

Case-Hardening. All but a few of the mildest steels can be case-hardened, and steels having a low carbon content are generally used for parts like the receiver shown in Figure 18, which have to be case-hardened — 0.2 percent carbon is usually the maximum amount allowable.

The soft, low-carbon steels are easy to machine, and are often used for parts that do not need to be case-hardened. This softening, however, might increase the difficulty of obtaining the fine finish needed for certain parts, especially when final grinding to exact size is difficult because of the shape or design of the part.

The nickel steels, without sacrificing any of the toughness, give a slight increase in hardness and fineness of structure, which provides the smooth surface essential for parts intended for case-hardening.

Alloy Steels. Good quality alloy steels contrast favorably with the plain carbon type. Great care is taken in manufacture resulting in lower impurities and greater tensile strength and ductility. However, alloy steels cost more to buy and machine than the plain carbon steels. The only practical drawback to the use of these steels in machines is that the surface is never thoroughly hard.

The more common alloys, such as manganese, chromium, and molybdenum, in addition to nickel, are all very effective in facilitating hardening. They reduce the critical cooling velocity necessary for complete hardening. If sufficiently alloyed, hardening can be obtained even with slow rates of cooling, such as are associated with the normal cooling of large masses in air. Many gun parts are made from alloy steel, as shown in Figure 19.

Figure 19: Many modern semi-automatic and slide-action shotguns use a light alloy steel for receivers and other parts on the guns. Alloy steels combine strength with lighter weight.

WINCHESTER BARREL STEEL

A rifle barrel is simply a piece of steel with a hole in it, and with spiral rifling (or grooves) cut so that the bullet will spin fast enough to fly point-on. Winchester used barrels of plain carbon steel in their earlier firearms, which was composed of 0.14 percent manganese, 0.040 percent phosphorus, and 0.08 percent-0.13 percent sulphur. These metal barrels are sufficient for lead bullets at low pressures, or for rimfire cartridges with lead bullets. However, when using jacketed bullets at high velocities, problems develop.

When smokeless powder, high velocities, and higher pressures came into play in the 1890s, Winchester used nickel steel for some of their barrels, but still produced the plain carbon barrels well into the twentieth century, since lead bullets were still quite popular. Nickel steel was used until the mid-1930s, when Winchester changed to heat-treated chromium-molybdenum steel, which was called "Winchester Proof Steel." For a while, Winchester also used stainless steel barrels on some models, which were so stainless that they could not be blued. To color these barrels, they were first copper-plated. The copper was then turned black by another chemical process.

So, what will happen when you shoot jacketed bullets, like those shown in Figure 20, in early black-powder barrels at relatively high velocities, yet within safe working pressure? They will probably not blow up, but the barrel will be completely shot out in a few hundred rounds or less. In some cases, pieces of the soft steel rifling have emerged with the bullet to be lost forever downrange.

Therefore, those who shoot their antique rifles should heed the recommended velocities and use only lubricated lead bullets. If you want to shoot at high velocities with jacketed bullets, have the rifle rebarreled if the gun is not in the collector class.

Figure 20: The type of bullet and the velocity at which it leaves the muzzle has a lot to do with how long a rifle barrel will last.

RESTORING GUN METAL

Before any firearm can be refinished (blued, browned, Parkerized, etc.), the metal must first be prepared to accept the new finish. All of the old finish is removed and the metal is polished and degreased. However, in some cases the metal is in poor condition for conventional polishing. Pits, dings, broken parts, and the like all account for additional work.

Where the metal is in really poor condition, it is usually best to leave the gun as is. Most attempts to put on a new finish will look worse than the old. If you have the time, a complete restoration of almost any firearm is possible. Dings or gouges in the metal, for example, appear in the form of raised craters on the steel. You can take a ball-peen hammer and lightly tap to peen every bit of the metal back into its original place.

Once this is done, a light polishing will make the metal look like new with no trace of the crater. As you peen the metal this way, you are actually forging the metal and causing it to flow. In doing so, the flowing metal will take the course of least resistance to move back to its original location. Most nicks and dings can be peened back in place in less than 15 minutes.

If the metal is gone, as in pits and holes in the metal, the metal be must replaced. The location and the depth of the pits will determine which method to use. If the pits are shallow, the surrounding metal can be polished to the level of the pit bottoms, thus removing them. However, if they are very deep, the pits must be filled in with a welder. Some gunsmiths have good results with spray welding. Both methods are complicated and beyond the scope of this course. Until you gain the necessary experience to do this type of work, it is recommended that you "farm out" all such work to those who specialize in replacing metal.

Pits on round barrels can be removed with a belt sander, which places the barrel in a spinning fixture. Pits on octagonal barrels, with flats running the length of the barrel, can be removed by draw-filing or by using a flat-bench honing stone. Many gun shops that can afford a power grinder use it for this operation.

Consequently, restoring the metal of firearms to its original condition takes a combination of techniques, including the following:

- Using a rust-penetrating oil to loosen screws, pins, and other parts to allow complete disassembly of the firearm with damaging any parts.
- Removing the old finish with a blue/rust remover.
- Peening any gouges or nicks to make the raised metal flow to its original position.
- Filling any large pits or holes by welding.
- Repairing or replacing any broken parts.
- Polishing and cleaning the metal surface so that it is ready for the new finish.
- Refinishing the metal with a type of finish compatible with the era in which the gun was built.

Obviously, there is much detail to each of the above operations, and every gun will present a different set of problems. Therefore, you must evaluate each gun on its condition, its value, and the methods needed to restore it.

Figure 21: The Winchester Model 94 carbine has gone through many bluing methods since its introduction 1894, beginning with the slow rust and nitre methods through the hot caustic method, which began about 1939.

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Obtaining Original Metal Finishes

The previously described methods of finishing gun metal should suffice for virtually all gun refinishing that a gunsmith will encounter. However, there are a few other recognized methods and formulas that have been used in the past that might benefit certain gunsmiths who want to specialize in restoring antique firearms, experiment with different methods, or know how certain guns of the past were refinished.

When an ordinary firearm is to be refinished, a gunsmith normally uses the hot caustic method unless the firearm is a double-barrel shotgun with soft soldered barrels or with a soft-soldered barrel rib or sight ramp. If this is the case, use the hot water process or the slow rusting process. Certain classic guns of the past, however, can be treated differently. For example, Parker shotguns have become a prized possession among gun collectors. Some models are valued at $100,000 so these guns should be left as they are because any type of refinishing at all will lower their value considerably.

On the other hand, the finish of the gun might be so poor that it would have little value to a collector, but could be restored as a hunting arm. In this case, the reconditioning of an old gun, provided it is not completely beyond repair, is perfectly legitimate. When repairing a gun for hunting, make an effort to follow the original finishing process, if this is known, or at least one of the processes used during the period in which the gun was constructed.

Modern hot caustic bluing salts are so similar to the old finish that it doesn't make much difference which brand to use to restore a modern gun. However, if you want the new finish to look like the original finish, use the bluing chemicals used by the gun manufacturer. For example, Colt, Savage, and other arms have been using bluing salts manufactured by Heathbath Corp. To find this information, contact the manufacturer of the firearm.

CHEMICAL USE SAFETY

All chemicals carry varying degrees of hazardous exposure. It is essential that you undertake basic safety precautions when dealing with dangerous compounds.

- First and foremost, know what you are dealing with! There are different types of chemicals, which come in various forms: liquid, gas, vapor, dust, fume, or mist. Before handling any chemical, understand its properties, how it is used, and how it must be handled to avoid harmful exposure.
- Know what to do in case of emergency! Using safe practices when cleaning up leaks or spills and knowing when to call emergency help will minimize harmful effects.
- Always wear protective gear when dealing with any chemical. A rubber shop apron, gloves, and boots , as well as a face shield and hat should be worn at all times.

Figure 22: Proper safety gear is essential.

- Mix all chemicals in well-ventilated areas, preferably outdoors.
- In case of contamination, wash all skin thoroughly, and , if necessary, dispose of clothing. If clothing can be safely laundered, wash separately after rinsing items outdoors using a hose or washtub.
- Never bring food into an area where chemicals are being used or stored. Wash hands, or shower and change clothes before eating.
- Keep the work area free from contamination by properly cleaning up spills immediately, and appropriately disposing of hazardous material.
- Know the proper way to store or dispose of any leftover chemicals.
- Make sure at least one other person is available to undertake emergency measures should you become incapacitated from harmful exposure.

BROWNING FORMULAS

The browning formulas listed have been tried and used by many gunsmiths. If you decide to use them, remember that most bluing or browning solutions contain poisonous chemicals and it is recommended that you have a druggist or chemist mix the solutions. Furthermore, you should seek a chemist's advice regarding further use and safety concerns. Follow safety procedures as you would for any other product in the home that contains poisons or caustic chemicals.

Browning Solution No. 1. This solution has been around for more than 60 years and has been used by hundreds of gunsmiths with excellent results. Mix the following:

1 oz. tincture ferric chloride

1 oz. alcohol (95 percent by volume)

¼ oz. bichloride of mercury

¼ oz. nitric acid (specific gravity 1.40)

⅛ oz. copper sulphate

1 quart distilled water

Do not store this mixture for longer than a few days. Mix the amount you need a few days prior to using and store in a brown glass bottle with acid-proof stopper or cap. Apply the solution as recommended.

Browning Solution No. 2. Here is a relatively old formula that was used around the turn of the twentieth century to brown Damascus barrels that were common on many side-by-side double-barrel shotguns.

½ oz. of sweet spirits of nitre

¼ oz. of tincture of steel

½ oz. corrosive sublimate

4 grains of nitrate of silver

¼ teaspoon of chalk

1 pint of distilled water

60 drops of aqua fortis

Handle the above chemicals with caution. This solution is poisonous and highly corrosive. Mix the chemicals outdoors and do not breathe the fumes emitted during mixing.

Browning Solution No. 3. A similar formula to the one mentioned above, it works better on some steels than the other solution. However, it has a tendency to etch the steel more.

1 oz. of sweet spirits of nitre

¼ oz. of tincture of steel

¼ oz. of blue vitriol

6 drops of nitric acid

14 grains of corrosive sublimate

1 pint of distilled water

SLOW RUST BLUING FORMULAS

Slow Rust Bluing Formula No. 1. This solution will give a light blue-black color to metal. It is somewhat slower than solutions used in the hot water bluing process, but faster than most slow rusting methods. Mix the chemicals outdoors. Do not breathe the fumes. Store the solution in a dark brown bottle with an acid-resistance cap or stopper. Label this and other bottles **Poison**.

4 oz. of hydrochloric acid

½ oz. of nitric acid

1 lb. of ferric chloride

½ oz. of copper sulphate

1 gallon of distilled water

Avoid getting this and all other formulas on your skin since they are highly caustic.

Slow Rust Bluing Formula No. 2. This is the basic slow rust formula used for rifles such as the one in Figure 9 on page 62. The first two ingredients are mixed outdoors and poured into a glass container. A considerable amount of heat and fumes will be generated so be careful. Then carefully drop in the nails. Be careful not to let any of the solution splash on you during the process. Wear safety goggles and rubber gloves as well as other protective clothing. Stir the mixture gently with a glass rod and let the mixture sit for an hour or until the nails have been dissolved by the acids. Pour the distilled water into an empty milk carton made of plastic or a glass jug. Note that we said pour the water into an empty container. *Never pour water into an acid solution.*

Slowly pour the acid solution into the jug with the water. Do this very slowly to avoid splattering. Let the solution "cure" for a couple of weeks and then pour the clear liquid into a dark glass jar. Leave the residue on the bottom of the milk carton in the carton. Do not pour this into the dark bottle with the clear liquid. Use as described for slow rust bluing as previously described. You will need:

4 oz. of nitric acid

3 oz. of hydrochloric acid

½ lb. of small clean iron nails

1 quart of distilled water

Again, label the container Poison and handle this as you would any other dangerous chemical. By this time, you might think that safety is over-emphasized, but you cannot get careless with chemicals without having dangerous and possibly lethal results. As long as you are careful, it is a safe operation.

Slow Rust Formula No. 3. The following formula has been standard at the Savage Arms plant around the early part of the twentieth century for browning certain firearms. Currently, they use the hot caustic solution supplied by Heatbath Corp. of Springfield, Massachusetts, except for certain soft soldered guns that are refinished. The solution is applied to the metal parts as described previously, but a steam cabinet is used to hasten and improve the job. Mix the following chemicals outdoors:

1½ oz. of mercuric chloride

1 oz. of copper sulphate

1 quart of distilled water

Dissolve the solids in the distilled water and then add:

4½ oz. of spirits of wine

1½ oz. of tincture of ferric chloride

1½ oz. of ethyl nitrate

¾ oz. of nitric acid

Store the solution in a dark brown bottle with an acid-proof stopper. Use as described previously.

Steam for about 3 hours between carding. This formula will give a durable, slow rust bluing job in approximately 24 hours that will surpass most factory jobs today.

Hot Water Bluing Formula No. 1. This formula has been used by many gunsmiths throughout the country with excellent results on most steel barrels. The formula is over 60 years old and has been tested to produce the desired results when using the hot water method of bluing. Mix the following powders in a clean, glass jar:

¼ oz. of sodium nitrate

¼ oz. of potassium nitrate

½ oz. of mercuric chloride

½ oz. of potassium chlorate

Heat 10 oz. of distilled water (warm but not boiling) and pour slowly into the container holding the mixed powders. Stir continuously with a glass rod until the solution cools. Add ½ oz. of ethyl nitrate. Pour the solution immediately into a brown glass or plastic bottle (use an acid-proof cap) and keep in a dark place until ready for use. Label the bottle "Poison" and "Shake Well Before Using."

Hot Water Bluing Formula No. 2. Stainless steel barrels are very difficult to color by any conventional method because bluing or browning is merely a rusting process. These steels are highly rust-resistant. The late Clyde Baker, in his book *Modern Gunsmithing*, suggests the addition of ½ oz. tincture of ferric chloride, ¼ oz. nitric acid, and ¼ oz. hydrochloric acid to the Hot Water Bluing Formula No. 1 (above) for coloring stainless steel. Use the methods previously described. However, two or three dozen applications might be required to do the job because the coloring is very slow. Mr. Baker's book was first published in 1928 and is now available from online book retailers.

Hot Caustic Formula No. 1. This formula is easy to mix and use. Your biggest problem will be finding the chemicals in small enough quantities to make the mixing worthwhile.

15 lb. of sodium hydroxide (flakes)

7½ lb. of ammonium nitrate

3 gallons of pure water

Mix the first two ingredients dry. Place the three gallons of water in your bluing tank and slowly add the mixed powders. Mix well. Add only a little at a time because heat will be produced as they are dissolved in the water.

Wear protective clothing, eye protection, and rubber gloves. When the chemicals are completely dissolved, heat the solution slowly until it boils at about 285° F. If the solution boils before this temperature is reached, add a little

more of the dry chemicals (mixed in the same proportion: one part ammonium nitrate to two parts sodium hydroxide) or let the water evaporate until the solution boils between 285-290° F.

When using this formula, a considerable amount of ammonia gas is given off and must not be inhaled. Use plenty of ventilation and be especially careful when you have to get near the tanks since a good "shot" of the ammonia gases can almost knock a person down.

As with most hot caustic methods, this formula will eat soft soldered joints. Do not blue double-barreled shotgun barrels that are joined this way. Also, rifle barrels with soft soldered ramps should not be blued in this solution. Use one of the hot water methods for these types.

SUMMARY

One way to gain experience is to buy some older guns to restore. There are many old shotguns (black powder) on the market. Many can be purchased at gun shows for less than $200.00. This will not only give you the experience, but will also provide you with a way of demonstrating the type of work that you can perform.

Finally, be sure that you know the type of material that you will be working with. Different types of metals react in different ways to the same procedures. Do not be surprised if the metal of one firearm reacts different to the same bluing operation. Most likely, the metals have a different alloy.

NOTES

Chapter 4: Modern Firearm Finishes I – Spray-on Finishes And Preparation

Introduction to Modern Firearm Finishes

With the constant evolution of science and technology, finishes and coatings have become more than just aesthetic or protective. Much of the technology for modern firearm finishes is trickled down from the automotive (racing) and aerospace industries. Modern finishes not only provide protection against corrosion and wear, but also lubricity and heat resistance/dissipation as well. Many modern firearms will use various coatings for different parts and purposes.

The following is a guide of the most popular coatings used in the firearms industry today. This guide is arranged in order, from coatings that can easily be applied with minimal tools and materials at home by the average hobbyist or gunsmith, to coatings that require specialty equipment and special care because of safety or environmental concerns. This guide also features some "how-to's" for many of the popular do-it-yourself coatings.

TYPES OF FINISHES

There are many types of finishes, all with their own advantages and disadvantages. There are also various methods of application, from spray-on to baths, or even with electricity. Even finishes that may seem similar may vary in chemical composition or purpose.

Coatings can be classified into two subcategories based on their bond type: mechanical and chemical. Finishes that utilize a mechanical bond rely heavily on surface finish for their adhesion as the coating needs to interlock with the surface's

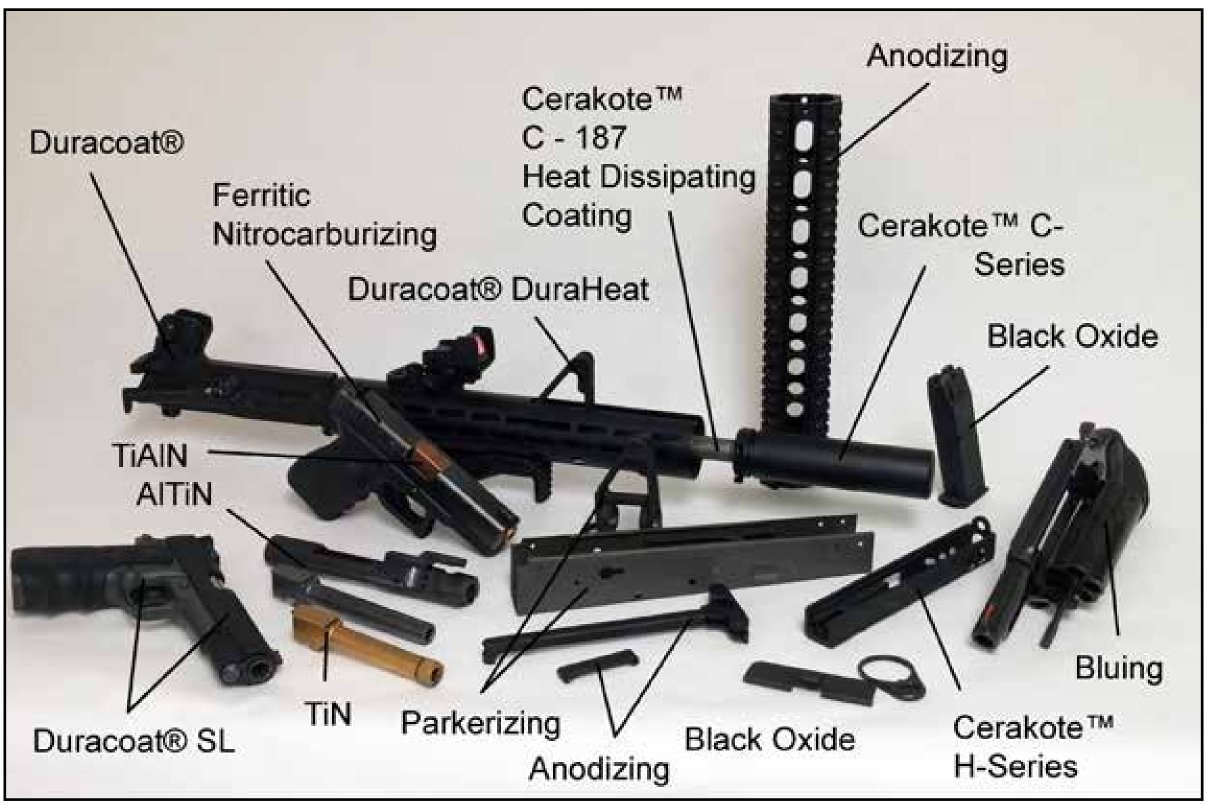

Figure 1: Modern firearm finishes.

structure of the part. These finishes will always add to the overall dimensions of the part being coated in thicknesses from .0002 in. to .004 in. Common mechanical bond finishes include spray-on finishes, plating finishes, and physical vapor deposition (PVD) coatings.

Finishes that utilize a chemical bond rely more on chemical makeup. These finishes use a combination of chemicals: heat and controlled environmental conditions to convert a thin layer of the material's surface into a new material that is bonded on a molecular level. This is why chemically bonded coatings are referred to as conversion coatings. Because conversion coatings convert the surface layer of material, there is little to no dimensional build-up (.0001 in. – .002 in.). Common conversion coatings include passivation coatings, phosphate conversion coatings, and ferritic nitrocarburizing.

Both mechanical and conversion coatings are used in order to protect the underlying part. They are designed to provide protection from oxidation and other forms of corrosion, provide chemical resistance, and provide protection from wear and abrasion. They may also be designed to provide lubricity to the part or help to reduce friction. Modern coatings may also be used to shield a part from heat, to dissipate the heat, or to withstand extremely high temperatures. Even with all of the advantages of modern finishes from protection to performance, they never stop providing an aesthetic appeal. With so many options available, you can be sure to find one that meets your specific needs.

Spray-On Finishes

Spray-on finishes are some of the most versatile modern coatings, capable of performing many roles at once. Spray-on finishes were originally designed to be barriers between the parts and the elements and did not offer much of anything else. They were not very durable or tough and could not stand up to harsh chemicals or withstand heat without bubbling, burning, or peeling off. Modern spray-on finishes are a huge leap forward in terms of protection and performance. Not only do they provide a barrier between the part and the elements, in many cases they are extremely durable, impact-, abrasion-, and chemical-resistant, and provide lubricity while adding only minimal dimension (.0005 – .004 in.). There are also some spray-on finishes that can withstand temperatures up to 1,500° F, or help to draw heat away from the part and dissipate it faster. Although some coatings offer many benefits, there is not a single coating that fulfills every need. Understanding the capabilities of specific coatings will allow you to choose the right one for your application. Spray-on finishes are categorized as thin film coatings.

It may seem like all spray-on finishes are similar and that is partially correct. Much of the parts preparation and application processes are similar, but that's where the similarities end. Chemical make-up, additives, coating preparation, and curing will all differ with each type of coating.

There are two main types of spray-on finishes: urethanes and epoxies. Urethanes and epoxies are both types of reactive polymers, meaning they start as a liquid, and through a reaction from a hardener or exposure to air, they begin to harden. Again, they may seem similar but their material properties are what make them very different.

Both urethanes and epoxies offer excellent abrasion, wear, chemical resistance, and toughness, but they accomplish it in different ways. Urethanes are capable of being as soft as an eraser

Figure 2: Different spray-on finishes.

or as hard as a bowling ball, but they will always retain their elastomer properties. Urethanes are true elastomers, meaning they will flex under stress and rebound to their resting position. Because of their flexible nature, urethanes are better equipped to withstand impact.

Epoxies are capable of being hard and harder. Epoxies exhibit exceptional strength and hardness and minimal elasticity. Because of their hardness, epoxies are more resistant to wear and abrasion. Both epoxies and urethanes are also able to accept additives (lubricants, UV stabilizers, flexibilizers, texturizers, etc.) without affecting performance.

Coatings also differ in their preparation and curing process. With some coatings, preparation may be as simple as opening the container and pouring it into the spray gun or airbrush. These are known as one-part coatings. These coatings come complete with everything needed to properly cure. The curing process is either activated by exposure to air (air cure) or by the introduction of heat (thermoset). One-part coatings can be thinned with the use of a reducer or other chemical to make application with certain tools easier.

Two-part coatings use a base/resin and an activator/hardener. Like one-part coatings, two-part coatings may also be air-cured or thermoset-cured. Two-part coatings may also use some type of thinner or reducer to promote easier application. Air-cured coatings rely on a chemical reaction between the air and chemicals in the coating to join and bond chemical chains and form the coating's material structure.

Thermoset coatings require heat to bond the chemical chains and harden the coating. Some of the most popular spray-on coatings include Duracoat®, Cerakote™, KG Gun-Kote, and Brownells® Aluma-Hyde II.

Duracoat is a two-part, urethane-based, air-cured finish that is remarkably durable and can withstand temperatures up to 600° F. It is available in 330+ colors in over 24 collections. Collections include standard colors, metallics, pearls, fluorescents, clears, high temperature, and phosphorescents. Duracoat also produces many of its collections and colors in an SL (self-lubricating) variant, which features a proprietary lubricant that provides reduced friction, longer wear life and a nonstick surface. Duracoat is also available in a liquid form (for spray guns and airbrushes) or in a convenient aerosol can. They also produce one-part high temperature coatings that can withstand temperatures up to 1,500° F and aerosol thermoset coatings.

Duracoat application is very simple and its versatility makes it perfect for the average at-home hobbyist or professional finishing shop. For best results and surface finish, Duracoat should be applied with an airbrush or with a conventional or HVLP spray gun at thicknesses between .00025 in. and .003 in. For most applicators, the two-part air cure Duracoat will be the most popular choice because of its ease of use and available color palette. For those who do not have accesses to a compressor for use with an airbrush or spray gun, Duracoat offers several finishing kits with aerosol coatings and aerosol applicators for the standard coatings.

Cerakote is a two-part, ceramic/epoxy-based, thermoset finish that is also extremely durable and abrasion-resistant. It can withstand temperatures upward of 500° F. Cerakote is available in 150+ colors in five collections, including the standard finishes, metallics, high temperature coatings, clears, dry film lubricant coatings and low IR (infrared) signature coatings (military and law enforcement only). Cerakote C-110Q Micro Slick is an air-dried, thin film lubricant (.00025 in.) coating used to reduce friction on

moving parts and has a blue/gray appearance. Cerakote C-Series high temperature coatings are one-part air cure finishes that can withstand temperatures between 800° and 2,000° F depending on color (white being the low end and black on the high end of the spectrum).

Cerakote is simple to apply and is not beyond the average hobbyist capabilities, but is better suited for the professional finishing shop. For best results and surface finish, Cerakote must be applied with an HVLP spray gun at thicknesses from .0005 in. to .0015 in. For the average hobbyist (who does not have access to an oven), the one-part, air cure C-Series will be the best choice because of its ease of use. For individuals who have access to an oven or professional finishing shops, the two-part thermoset H-Series will provide the best overall performance of all the Cerakote coatings.

KG Gun-Kote is a one-part thermoset epoxy finish that is exceedingly durable and offers considerable friction-reducing and heat-dissipating properties. Gun-Kote can withstand temperatures between 500° and 800° F. KG Gun-Kote is available in 140+ colors in six collections, including air cure, the original 2300 Series Black, 2400 Series standard colors, metallics, NaNo Series, and Site Kote. KG Gun-Kote employs molybdenum disulphide to provide its lubricity. The NaNo Series coatings are Gun-Kote's premier product line offering increased protection, lubricity, abrasion and scratch resistance, and heat dissipation over the 2300 and 2400 Series coatings. The 1200 Series is a one-part air cure coating developed for parts that cannot be subjected to heat and can be applied to rubber.

KG Gun-Kote is also simple to apply and requires heat to cure it, similar to Cerakote. Gun-Kote differs from the other coatings because it requires the parts to be preheated to between 100° and 120° F before application. For best results and surface finish, Gun-Kote should be applied with an HVLP spray gun at a thickness of ~.0004 in. For the average hobbyist (who does not have access to an oven), the one-part air cure 1200 Series will be the best choice because of its ease of use. For individuals who have access to an oven or professional finishing shops, the one-part thermoset NaNo Series will provide the best overall performance of all the Gun-Kote coatings.

Brownells Aluma-Hyde II is a one-part/two-part, heat set/air cure epoxy finish that is fairly durable, abrasion-resistant, and extremely chemical-resistant. Aluma-Hyde II can withstand temperatures up to 500° F and is available in an aerosol can (12 colors) and a liquid (3 colors) for use with spray guns. Aluma-Hyde II is fairly easy to apply, especially in aerosol form. The main difference between Aluma-Hyde II and other coatings is that even though it is air-cured, the parts must be preheated and each coat of paint must be set with heat (an oven, a heat gun, or hair dryer). Aluma-Hyde II can also be applied with an airbrush or spray gun in thicknesses from .001 in. to .003 in. Aluma-Hyde II is suited for use with both hobbyists and professional shops.

WHAT CAN I COAT?

A simpler question would be, *what can't be coated*? The selection and versatility of modern spray-on coatings will allow you to coat almost anything. With little to no preparation, spray-on coatings can be applied to metal, wood, plastic, and even rubber. This means with the appropriate coating, every part of a firearm can be coated inside and out (with the exception of the chamber and bore). This includes receivers and actions, bolts and carriers, fire control groups and other moving parts, springs, stocks and furniture, sights, accessories and optics (with the exception of the glass).

Often, the material of the part and its intended use will dictate which coating you choose. The biggest deciding factor is heat. Parts made of woods and certain plastics, rubber, or some optics cannot withstand the high temperature cure

required for thermoset coatings. This makes air cure coating the only available choice for these parts. Other parts, like pistol slides that will see a lot of slide wear, require a coating that is very hard or abrasion-resistant. This makes thermoset coatings a better choice as they are typically much tougher than air cure coatings with the exception of Duracoat.

Regardless of the material of the part, there is some degree of surface preparation required for proper adhesion. This will also have some bearing on coating choice. In the end, what you can coat is going to be based on your available equipment, your skill, and level of confidence coating certain parts.

FIREARM DISASSEMBLY

For most guns, all you will need is basic gunsmithing tools like screwdrivers, punches, small hammers, Allen keys, wrenches, blocks, and vises. Some firearms also require proprietary wrenches or tools to disassemble completely. Sometimes, small parts or certain parts are not coated and need to be stored. Small sandwich bags are perfect and can be written on with a permanent marker to label the parts. Small boxes and containers can also be used to hold different size parts and keep everything stored neatly. With guns you are unfamiliar with, you may also want to take pictures during the disassembly process to help when you have to put it back together.

TOOLS AND MATERIALS LIST

Proper application of most spray-on finishes requires a fair amount of equipment and materials. First, the parts all need to be removed or disassembled from the gun. After the parts are separated they need to be cleaned and prepared. Finally, the coatings are applied and must be cured. After spraying, the spray gun needs to be cleaned and all equipment must be maintained. All of these steps require a minimum amount of tools and materials to apply a spray-on coating properly. The following material will cover a list of the minimum tools and materials needed to properly apply spray-on finishes. The list is sorted by order of steps involved.

Figure 3: Gunsmithing tools.

Cleaning and Preparation

These are the basic tools and materials needed to clean and prepare parts.

- **Acetone**. Acetone is a fantastic cleaner and will remove any dirt, oil, or other residue from the part's surface. Once acetone dries it leaves the surface clean and dry and ready to rough. If you try to prepare the part's surface while it is dirty or oily, you will contaminate your abrasive media and imbed dirt and oil into the part's surface. Be aware that acetone is fairly harsh and will damage some materials. You may have to test a small area of the part to verify. If acetone is too harsh for a given material, denatured alcohol can be substituted.

- **Bins or Tubs**. Plastic bins or tubs are useful for bathing parts in acetone. Different size bins or tubs will allow you to work with any size firearm. Bins or tubs with lids make storing the acetone easier for use again.

- **Rags or Paper Towels**. Rags and paper towels are used for wiping down parts and cleaning them. Even after parts soak in acetone, there may still be some built-up dirt that rags can't remove. Small brushes may also come in handy. Try to use rags or paper towels that produce the least amount of lint.

- **Gloves**. Gloves are very important when cleaning parts and working with acetone. Lead and other residue is present in the action and bore of firearms and wearing gloves will protect you. Gloves also protect the part from contamination from natural oils from your skin. Once the preparation and paint process has begun, you should wear gloves anytime you handle parts. Latex gloves provide good protection from exposure to lead, acetone, and other chemicals and are fairly cheap.

- **Dust Mask and Safety Glasses**. A dust mask and safety glasses will protect your eyes and lungs from fine particulate created while roughing the parts surface. Safety precautions must always be employed anytime risk of injury or exposure is present.

Figure 4: Materials and tools used for cleaning and preparation.

- **Abrasive Blast Cabinet or Other Abrasives**. An abrasive blast cabinet is required for the majority of spray-on finishes. Other finishes only require the surface to be roughed with sandpaper or scuff pads. A blast cabinet is used to strip old finishes or coatings off completely and fairly quickly. A blast cabinet will give you the best, most uniform surface finish, but will also abrade every surface inside of the cabinet. Surfaces that cannot be blasted or are not being coated must be masked-off or plugged. For more delicate parts or parts that cannot be blasted, sandpaper and scuff pads are the best choice. Sandpaper in different grades from 320- to 600-grit are perfect for roughing-up the part of the surface enough for coatings to stick. Red scuff pads also come in handy because of their ability to conform to the surface of the part, making tough-to-reach areas easier to abrade.

- **Blast Media**. Aluminum oxide is the best medium for stripping old finishes or roughing a new one. Aluminum oxide is hard enough to scratch any material, but will not embed in the surface like glass beads. Glass beads should never be used to prep parts' surfaces. The best grits for blasting parts are 100 and 120 at similar psi's. Over time, extended use will break the media down into finer grits and new media will have to be added.

- **Masking Tape**. Masking tape is used to protect areas of the part that you do not want blasted or painted. There are specialized masking tapes just for media blasting, that are thicker and do not peel. Regular painter's masking tape works just fine if you double or triple up on the layers and don't blast too hard against the tape. Having various widths (¼ in., ½ in. and 1 in.) will allow you to tape various shaped and sized pieces.

- **Plug Kit**. Plugs are used to block areas like bores, chambers, and gas ports or other holes you do not want blasted or painted. Cerakote makes a fantastic plug kit consisting of 323 reusable plugs of various sizes. The kit is definitely worth the price (~$60 shipped) and will save time and much headache. The plugs are also capable of withstanding sustained temperatures up to 600° F.

SPRAYING AND CURING

These are the basic tools and materials needed to spray and cure parts.

- **Coating**. Most spray-on coatings use more than one chemical (even one-part coatings) to achieve the proper application. The following is a list of coatings and their required parts.
    - » Duracoat requires a hardener to properly catalyze. A reducer is also required for thinning in some spray guns/airbrushes, altitudes, and temperatures. Duracoat also offers UV-resistant additives for high UV use parts, retarders that prevent dry spray, and flex additives that make the coating more flexible for use on rubber parts.
    - » Cerakote only requires a catalyst.
    - » KG Gun-Kote is ready to spray from the bottle. MEK (methyl ethyl ketone) or ethyl alcohol can be used for thinning.
    - » Brownells Aluma-Hyde II requires Aluma-Hyde II Solvent & Thinner to achieve the correct consistency for spraying.
- **Spray Gun or Airbrush**. A spray gun and airbrush are used to apply the coatings. Each coating requires a specific psi and tip size to properly atomize the coating

Figure 5: Materials and tools used for spraying and curing.

for a smooth, consistent surface finish. The difference between the spray gun and the airbrush is overall size, tip size, and spray pattern size. Spray guns are much bigger than airbrushes and have the ergonomics of a pistol. The larger size requires a larger tip (~0.8mm), which produces a larger spray pattern. Airbrushes are much smaller and are similar to a pen or pencil. The smaller size of the airbrush requires a smaller tip (~0.5mm), which produces a smaller pattern (even as thin as a pencil line). For spraying larger parts with lots of surface area, the HVLP spray gun is your best option. It can also be tuned down to spray a smaller pattern, making spraying smaller parts and hard-to-reach areas easy.

- An airbrush is better suited to small parts and detail or touch-up work. An airbrush can spray larger parts, but it would just be running at full capacity with large surfaces. An HVLP spray gun is typically adjustable for psi, spray pattern size and shape, and material flow. An airbrush is typically not adjustable and the pattern is controlled by lever, and psi is controlled externally.
- **Compressor and Air Lines**. A compressor produces air pressure, and air lines transport it to the spray gun or airbrush. A compressor also is used to power the blast cabinet. The most important thing with compressor choice is the CFM (cubic feet per minute) of

airflow it can produce. psi is typically not an issue because the spray gun only requires between 20 and 25 psi and the airbrush uses about the same. The CFM requirements are what vary greatly, with airbrushes using between .5 and 1 and HVLP spray guns needing between 7.5 and 24. As a rule of thumb, a quality 5 hp rated compressor will typically produce ~3.5 CFM per hp, meaning a 5 hp compressor will produce about 17.5 CFM. Please note that these figures are typically at 60 – 90 psi, so at lower pressures it will deliver more CFM. Capacity is also important. A 5 hp compressor will typically have between a 60 and 80 gallon tank, which is more than enough capacity. Anything lower than about 30 gallons and you will find your compressor constantly running to keep up.

- Air lines are also important and can add capacity to your air system. You can connect the spray gun or airbrush directly to the compressor, so lines are used as a coupler. Air hoses are flexible and are good for short distances. A dedicated PVC air line can be routed around the garage or spray booth and can increase air capacity.
- **Air Filters**. Air filters are used to clean the compressed air. Sometime air and oil get into the air from environmental conditions or from the compressor's motor. This water and oil will contaminate the coating and ruin the finish. Water and oil separators will remove any contaminates from the air and leave it clean and dry. It would also be beneficial to run redundant filters to guarantee clean air. You may run one close to the compressor and one closer to the spray gun.

Figure 6: Materials and tools used for cleanup and maintenance.

- **Pressure Regulators**. Pressure regulators will control the air pressure. The compressor typically produces around 150 psi, which is way too high for spray-on finishes. Regulators will allow you to turn the pressure down to a useable 15 – 30 psi. Pressure regulators are available in analog form with a dial indicator or in digital form with a small LCD that displays pressure down to the ½ pound.
- **Respirator and Safety Glasses**. A respirator and safety glasses are absolutely required pieces of equipment when applying any spray-on finish. There is significant health risk with all spray-on finishes because the spray gun and airbrush "atomize" the coating, creating a fine mist, which, when inhaled, can cause significant health issues. Also, most spray-on finishes rely on VOCs (volatile organic compounds) as substrates for the coatings. When the coating begins to "flash off," the VOCs evaporate and are

released into the air. These VOCs can be harmful if exposed to them for short or prolonged periods. These reasons are also why eye protection is important. The half-face organic vapor respirator is perfect for this job and fairly inexpensive at around $40. The full-face model incorporates an eye shield and is more expensive (~$100).

- **Measuring Materials**. Cerakote, Duracoat, and Aluma-Hyde II must all be mixed at very specific ratios. The performance of the coatings is dependent on these ratios. For Duracoat and Cerakote the final sheen (flat to gloss) is controlled by the ratio of coating to hardener/catalyst. You can use small measuring cups and droppers, a graduated cylinder, or measuring spoons to meter your rations. Duracoat recommends measuring spoons (tablespoon and teaspoon) while Cerakote recommends a graduated cylinder.

- **Mixing Materials**. Multi-part coatings must be mixed to properly catalyze and provide a consistent finish. Spray-on finishes must be mixed thoroughly for several minutes for proper catalization. Popsicle sticks make cheap, fast stir sticks, and small bottles with lids will allow you to shake the coating until it is mixed.

- **Strainer**. Strainers are used to remove any large particulate that may have gotten into the coating. Sometimes, when a coating container is opened many times and not cleaned, dry coating will accumulate near the lid. When opened and closed, the dry material falls into the fresh coating. If not strained, these small particles can be sprayed onto the part's surface, which is very noticeable. After mixing, the coating is strained into the spray gun's hopper or paint bottle.

- **Cleaning Materials**. Parts must be thoroughly cleaned before coatings can be applied. Cerakote, KG-Gun-Kote, and Aluma-Hyde all recommend an acetone bath. Duracoat recommends its own cleaner, TruStrip™. You also need tubs or bins to soak the parts. Rags, paper towels, small brushes, and Q-tips can all be used to clean the parts and hard-to-reach areas. Any rags and towels used should be low lint to reduce the amount of cleaning.

- **Hangers or Wire**. Parts need to be hung while coating to allow 360° access to all of their surfaces. Hangers and wire are perfect for hanging parts. Metal hangers and wire can be bent and formed to fit the unique shape of each part. The wire should be thick enough and stiff enough to support the workpiece. The larger the workpiece, the thicker the wire.

- **Tape**. Tape is used to mask-off sections of the part that are not being coated. Painter's tape works perfectly for air cure coatings, and if it is removed before thermoset coatings are cured. For thermoset coatings, high temperature tape is the best choice. Cerakote offers several widths of high temperature tape.

- **Spray Booth or Spray Area**. You need an area reserved for applying spray-on coatings. The area should be well-ventilated and be clean and free of dust and debris. A dedicated spray booth will have built-in ventilation to circulate clean air and draw overspray away from the parts. A garage or small room or sectioned-off space can also be used. You want your spray area as clean as possible. Any dust

Figure 7: Media blasting and sanding.

in the air will deposit itself on the part's surface while spraying. Small plug-in fans can also be used to move air around. Your spray area also has to maintain a temperature of at least 65° – 75° F for parts to flash and cure. Small plug-in heaters can be used for this. The spray area should also feature provisions for hanging parts.

- **Oven**. For thermoset coatings, an oven is a must. For small parts or pistols you could use a small toaster oven or home oven, but for longer barrels, stocks, or barreled actions, you need a larger industrial oven. The oven should be able to reach at least 500° F and maintain a consistent temperature. Ovens can also be used to "gas-out" parts before media blasting. The oven should also have provisions for hanging parts.

Figure 8: Soaking parts.

Figure 9: Gassing-out parts.

CLEANUP AND MAINTENANCE

After coating is complete, you need to clean up the mess you have just created. Measuring equipment, the spray gun/airbrush, and the workspace all need to be cleaned. Cerakote and Aluma-Hyde II can be cleaned up with acetone. Gun-Kote can be cleaned with acetone or MEK, and Duracoat is cleaned up with Duracoat Reducer.

Some other helpful materials are:

- Rags and paper towels
- Q-tips
- Pipe cleaners
- Small brushes
- Small bins
- Small trash can and trash bags

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Parts Preparation

Spray-on coatings perform best when applied to a properly prepared surface. This means the surface of the part has enough "tooth" for the coating to "bite" and create a strong adhesion bond. The surface of the parts must be roughed to promote good adhesion but not so rough that the coating cannot level off over the small scratches. The surface must also be clean and free of debris. The performance of the coating is 100 percent dependent on the preparation process. Over time, you will discover that the actual act of applying a coating is only about 5 percent of the work and preparation is 95 percent.

To begin, the parts need to be disassembled and cleaned. The farther you can disassemble the gun, the better. Assemblies that can be removed as a whole should be, with no further disassembly of the subassembly. Package small parts and label them for reassembly later. Sort parts that will be blasted and painted and parts that will be left alone. Soak parts that are going to be blasted and painted in a bin of acetone to clean them. Any built-up dirt or residue should be removed before media blasting. Any oil present on the part's surface while blasting will contaminate the media and embed into the part's surface. Parts that cannot withstand an acetone bath can be soaked in denatured alcohol. Wood parts should be soaked in a degreaser to remove oil finishes. You should be wearing gloves at all times to prevent your natural oils from contaminating the part.

Once the parts have been cleaned and dried, areas that need to be masked-off are covered. Parts that can be media blasted should be placed in the blaster; parts that cannot be blasted are set off to the side. Each coating requires a specific blast profile to achieve the greatest adhesion. For all metal parts, plastic, and rubber parts, 100- to 120-grit aluminum oxide will work best. Metal parts can be blasted at 60 – 90 psi to achieve the best "tooth." Plastic and rubber parts can be blasted at ≤40 psi. You may have to test small areas of the part to assure it is not being blasted too hard. Try to achieve a uniform blast profile and full surface coverage. You can blast parts down to bare metal to achieve the best adhesion or simply "dust the surface" to achieve an adequate surface profile.

Wood parts or other parts that cannot handle being blasted should be sanded by hand with sandpaper and scuff pads ranging from 220- to 400-grit. You may have to sand and soak wood parts several times to remove the old finish. As a rule of thumb with blasting and sanding, if the part is shiny, the coating will not stick. The idea is to abrade the surface as much as possible so that the coating will bond properly.

Once the parts are blasted and sanded they must be blown-off/out. Use an air attachment and blow off all the media and dust and other particulate off of the parts. The parts are then soaked in acetone/alcohol once again. Remove the parts from the acetone and hang them with hangers or wire.

The parts need to be placed in the oven so they can "gas-out." *Gassing-out* means that the parts are heated so that any remaining oils still left behind will seep out of holes and crevices. To gas-out metal parts, they should be heated in an oven at 350° F for 1 to 2 hours. Plastic and wood parts should be gassed-out at 170° F for 1 hour.

You will notice stains around screw holes and other areas where the remaining oil has crept out. Soak the parts in acetone again and gas-out one more time. If there is no more oil seepage, you can lightly blast or sand the part one more time. For parts intended to be sprayed with Cerakote, Gun-Kote, or Aluma-Hyde II can be cleaned with acetone. Parts intended to be sprayed with Duracoat need to be cleaned with TruStrip.

Figure 10: Masking and plugging parts.

MASKING AND PLUGGING

Areas of parts that cannot be coated must be masked-off or plugged. Areas like chambers, bores, gas ports, slide rails, sear surfaces, or the glass of optics must be protected. Generally, painter's tape will be the best choice. For thermoset coatings, you will need a high temperature tape. Whichever tape you use, make sure the tape lays flat and the edges are pressed down. Wrinkles or raised edges will allow coating to creep underneath, leaving overspray on the masked surface and creating a sloppy line. Completely cover the area that is not intended to be painted; the fine particulate of the sprayed coating can get everywhere. Use a popsicle stick to run along the edges of the tape to assure full adhesion.

Plugs are used to close holes. The chamber and bore, gas ports, and screw holes should all be plugged. Pretty much any hole you don't want coating in should be plugged. Plugs should be pressed in place firmly to prevent them from flying out during spraying.

HOLDING PARTS

The way parts are held and secured while coating is very important. You do not want the hanger or wire to block or pass through an area that requires coating. You also want access to as much of the part's surface area as possible. You do not want to hang a part and begin spraying only to find out you cannot get to a certain spot without re-hanging the part. Hanging parts with holes is fairly simple. Simply hook the hanger or wire through the hole so it does not interfere with anything.

Parts that do not have holes are a little trickier to hang. They often require thin gauge metal wire

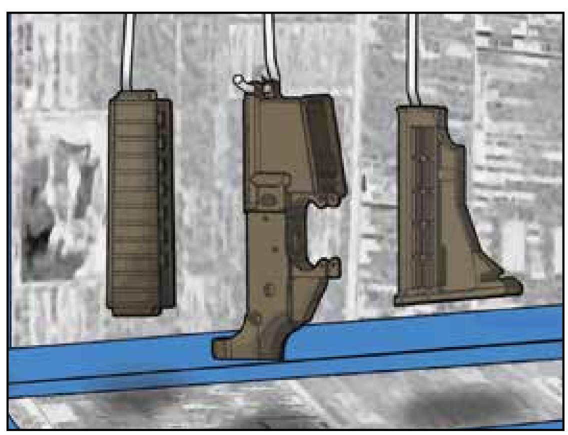

Figure 11: Hanging parts.

to be wrapped around them. The wire should be wrapped in an inconspicuous way and should not cover any areas that must be coated. When hanging parts, there is no way around the fact that a small area of the part will not get coating. The goal of properly hanging parts is to minimize this area.

You also have to consider the curing process. With thermoset coatings you have to move the part from the spray area into the over. You will not be able to re-hang the part, so you have to hang the part correctly the first time. You also want to make sure your hangers are clean and free of oil and other residue to prevent contamination of the part.

PAINT BOOTH PREP

Paint booth prep is as equally important as parts prep. If you spray clean parts with clean air in a dirty room, you are going to get dirt in your finish. The room should be completely free of dirt, dust, and any chemicals that could affect the finish, like acetone or other VOCs.

Start by sweeping and dusting the room. Dust the ceiling and walls and sweep the floors. Get into the corners and every nook and cranny. Let any remaining dust settle and sweep and dust again. Use compressed air to blow out the room, starting from the ceiling and working your way down the walls and onto the floor. Let the dust settle again and sweep and dust once more.

Hang the parts in the spray booth and use compressed air to blow any remaining dust or lint off of the part. Allow the dust to settle and sweep and dust once more. Once the dust has settled again, wet the floor (if applicable). A wet floor will trap any remaining dust and debris and prevent it from blowing around while spraying. Once the floor is wet, use compressed air again to blow out the spray booth and blow off the parts. Make sure to blow off yourself as well. Dust and debris and hair can be attracted to your body or clothes and come off and land on the part while spraying. Right before spraying, make sure the floor is still wet and blow the parts off one last time. This may seem like overkill, but it only takes one piece of dust or lint to ruin an otherwise perfect finish. You also want to make certain the booth is at least 65° – 70° F for proper adhesion and flashing of the coating. A booth that is too cold will result in runs and coating that will not flash or cure. You can use a small heater to bring your booth up to temperature.

Figure 12: Paint booth prep.

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Coating Prep

Figure 13: Mixing coatings.

Each coating will require a different preparation before it is ready to spray. Even one-part coatings require some prep before they can be sprayed. The following is a breakdown for each coating's preparation.

- **Duracoat**. Before any metering or mixing is done, Duracoat must be shaken. There is a glass ball in every bottle to assist with mixing the coating. Shake the bottle until you can hear the ball bounce. After hearing the ball, continue to shake for 2 – 3 additional minutes. Once the coating is fully mixed, you can begin metering the coating, hardener, and reducer if needed. Duracoat is mixed at a ratio of 12 parts coating to 1 part hardener. This ratio will produce a satin sheen finish regardless of color. A 14:1 ratio will produce a flat finish, while a 10:1 ratio will produce a gloss finish.

  You can use measuring spoons to meter your Duracoat. The ratio is 4 tablespoons of coating to 1 teaspoon of hardener. The amount of coating you mix will depend on the amount of parts you are coating. Reducer is used to thin the coating so it sprays easier. Reducer is used on a case-by-case basis as needed. Reducer can be added as much as 20 percent of coating volume. Typically adding an equal amount of hardener and reducer will provide the best results. For a complete pistol, including all small parts, you should mix ~2 tablespoons/1 oz. (½ teaspoon of hardener). For a complete rifle and a few accessories, you should mix ~4 tablespoons/2 oz. One 4 oz. container of Duracoat is typically enough to spray two rifles or up to four pistols.

  You should mix Duracoat in a separate container. Thoroughly mix the coating and hardener for 2 – 3 minutes. Use a paint filter to strain the coating when pouring into the paint cup or bottle. You can continue to shake the coating after it is in the cup/bottle. Duracoat needs to catalyze for a few minutes (~10) before spraying.

- **Cerakote**. Before any metering or mixing is done, Cerakote must be shaken. Shake the bottle for about 5 minutes. Once the coating is fully mixed you can begin metering the coating and catalyst. Cerakote is mixed at a ratio of 18 parts coating to 1 part catalyst. This ratio will produce a satin sheen finish regardless of color. A 24:1 ratio will produce a flat finish, while a 12:1 ratio will produce a gloss finish.

  Cerakote recommends using a graduated cylinder to meter the coating. The amount of coating you mix will depend on the amount of parts you are coating. For a complete pistol, including all small parts, you should mix ~36 ml/cc/~1.2 oz. (2 ml/cc of catalyst). For a complete rifle

and a few accessories, you should mix ~72 ml/cc/ ~2.4 oz. (4 ml/cc of catalyst).

You should mix Cerakote in a separate glass container. Do not mix Cerakote in a plastic container because it may compromise the coating. Thoroughly mix the coating and catalyst for 3 – 4 minutes. Use a paint filter to strain the coating when pouring into the paint cup. Cerakote should be left alone to catalyze for a few minutes (~5) before spraying.

- **KG Gun-Kote**. KG Gun-Kote is formulated to spray directly from the bottle. Before pouring Gun-Kote into the paint cup, shake it thoroughly for several minutes. Strain the coating through a filter before pouring it into the paint cup. If the coating must be thinned, you can use MEK or ethyl alcohol to thin up to 20 percent by volume.

  Brownells Aluma-Hyde II. Brownells Aluma-Hyde II is formulated to spray directly from the bottle. Before pouring Aluma-Hyde II into the paint cup, shake it thoroughly for several minutes. Strain the coating through a filter before pouring it into the paint cup/bottle. If the coating must be thinned, you can use Aluma-Hyde Solvent & Thinner to thin up to 20 percent by volume.

Once coatings have been mixed or poured into another container, they should never be returned to the original container. Once coatings begin to catalyze you have a few hours of "pot life" during which the coating is capable of being sprayed. Cerakote has a 2 hour pot life while Duracoat has around six. Mix only what you think you will need. You can always mix more but you can't save leftover coating.

SPRAYING

It is finally time to spray...well, almost. Before you begin spraying, you need to run a last-minute checklist to catch any mistakes in the process. You will also need to tune your spray profile. If you are using Gun-Kote or Aluma-Hyde II, you should begin warming your parts.

Examine the parts and the spray area one last time. Make sure the parts do not have any dust or debris. Double check your hanging and make sure you can spray the part without having to re-hang it. Examine yourself and make sure you don't have any dust or debris on you that could

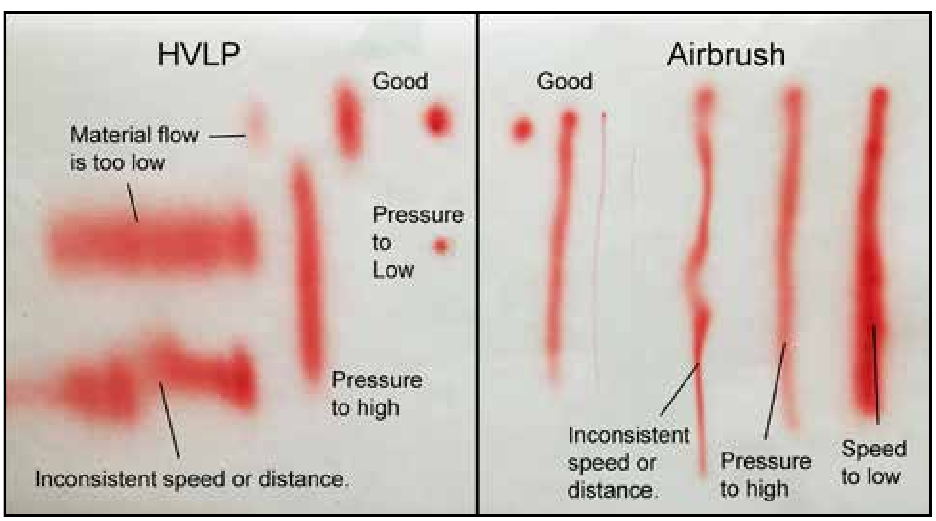

Figure 14: Adjusting the spray pattern.

get onto the finish. Make sure the floor is still wet and check the temperature.

You will also need to adjust your air pressure and spray pattern. Adjusting pressure is simple with a pressure regulator. Each coating has a specified psi range for proper application, which will vary based on applicator and environmental conditions. A general starting point for HVLP spray guns is 20 – 30 psi. A general starting point for airbrushes is 15 – 20 psi. Pressure should be adjusted while the trigger/lever is pressed on the spray gun/airbrush (without coating). This is the "working" pressure. If you try to adjust the pressure without pressing the trigger/lever, you will get a false reading and not have enough pressure to atomize the coating.

Now it's time to adjust your spray pattern. To conserve coating, you can spray water or acetone through the gun to adjust the pattern. You will need to make final adjustments with the coating because of differences in viscosity. An airbrush controls its pattern through an adjustable nozzle (single action) or through lever manipulation (dual action). An HVLP spray gun typically has adjustment knobs for pressure, pattern, and material flow.

To adjust the spray pattern of an airbrush or HVLP spray gun, all you need is some scrap paper. With an airbrush you want to be about 3 in. – 5 in. away from the paper at around 16 psi. The airbrush should produce a pattern between 1 in. and 2 in. wide. With an HVLP spray gun, you should be about 4 in. – 8 in. away from the paper at around 20 psi. An airbrush will produce a solid round, wet pattern with fading edges when it is set up correctly. The HVLP spray gun should also produce a solid, wet pattern, but its shape will vary from round to eclipse depending on the pattern adjustment. The spray pattern should be around 2 in. – 3 in. wide to avoid dry spray.

If the pattern looks splattered, you are not using enough pressure. If the pattern is consistent but light, you need more material flow. If the pattern is heavy and running, you have too much material flow. Refer to Figure 14 for the correct pattern profile.

Once the spray gun/airbrush is adjusted, you can finally start spraying. You just have to practice first. With coating in your spray gun/airbrush, you will need to fine tune your pattern. Now you can practice your application on a scrap piece of paper.

Both Duracoat and Cerakote need to be sprayed on "wet." This means that each pass completely covers the area sprayed and the coating looks wet (Figure 15). Full coverage will be achieved in one to two passes. Gun-Kote and Aluma-Hyde II are both applied in light, misting passes. Although the passes are "light," the coating

Figure 15: Wet pass.

Figure 16: Light pass.

particles are still wet when they hit the part's surface. Full coverage may take up to four to five passes. Regardless if the pass is wet or light, it should be consistent and even. The spray gun/airbrush should be kept at a consistent distance from the part's surface as it travels over all the parts' surfaces. Moving the spray gun/airbrush closer and further away from the part will lead to inconsistencies in the coating's thickness. The speed at which you move the sprayer across the part's surface is also important. Moving too slowly will cause the material to build up on the part's surface, while too fast will lead to light areas.

When you feel like you have the spray pattern tuned and you have a feel for the speed and distance of each pass, you can begin spraying your parts. Begin with the inside of parts, holes, and hard-to-reach areas. Parts should always be coated from the inside out to avoid buildup or runs. Spray each area from multiple angles to assure you are getting full coverage. Make one full pass, inside and out, taking great care to apply the coating evenly and consistently. With Duracoat, Cerakote, and Gun-Kote, allow the coating to flash off for 5 – 10 minutes. Flashing occurs when VOCs begin to evaporate and the coating begins to cure on the part's surface. When the coating starts to cure, it becomes tacky. This tackiness prevents subsequent layers from sagging and running. If you are using Aluma-Hyde II, you will need to heat-flash the coating in between passes. Using a heat gun or hair dryer for 30 – 60 seconds brings the temperature of the part up to around 100° F. Do not allow Aluma-Hyde II to flash more than 15 minutes between passes; if so, you have to let it cure for 48 hours and sand and respray.

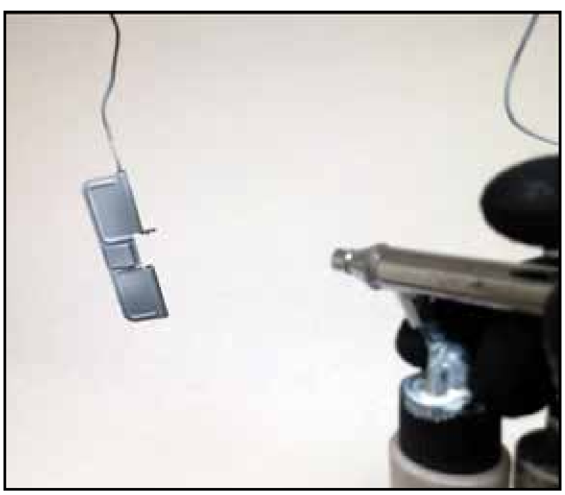

Figure 17: Spraying parts.

Once the coating has properly flashed, you can begin spraying additional coats. Cerakote recommends 1 – 2 coats, equaling .0005 in. – .001 in. Duracoat can be applied from 1 to 5+ coats, equaling .00025 in. – .003 in. Gun-Kote recommends many light passes until full coverage is achieved at a thickness of ~.0004 in. Aluma-Hyde II should be applied in several light coats until full coverage is achieved at a thickness of ~.002 in.

Take a minute to examine the parts and make sure you have achieved complete coverage. If you have any debris or dry or runny spots, you can strip the coating off with acetone, clean the part, and respray. If you are satisfied with your results, you can begin the curing process.

CURING

If you are using Duracoat or Aluma-Hyde II, all you have to do is wait (or not). You do, however, have to make sure the curing area stays between 75° and 90° F for the parts to cure properly. Duracoat is dry to the touch in 20 minutes, cured enough to handle in 1 hour and can be reassembled in 24 hours. It reaches full cure at around four weeks. Duracoat can also be cured faster at elevated temperatures. Baking for 1 hour at 115° F will speed up the assembly time. Aluma-Hyde II can take up to 24 hours before it can be handled and reaches full cure at 7 – 10 days. Cure times will depend on the curing room's average temperature and relative humidity.

Figure 18: Thermoset curing.

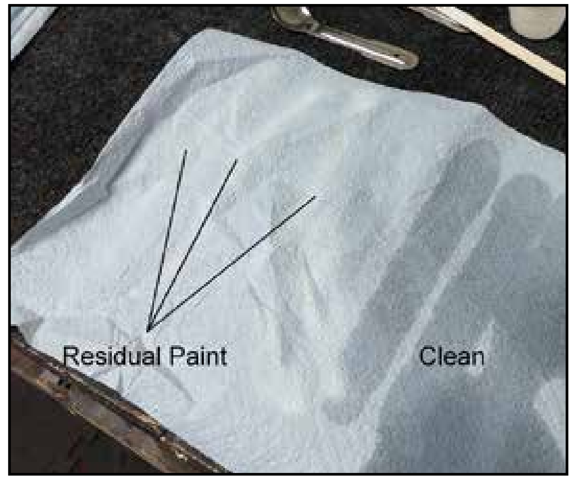

Figure 19: Equipment cleanup and maintenance.

Cerakote and Gun-Kote must both be thermoset. Parts coated with Cerakote should be allowed to flash for an additional 10 minutes before being baked. Cerakote can be cured a few different ways depending on the material of the part. Basic cure is 2 hours at 250˚ F for all metals. You can cure it faster at 300˚ F for 1 hour. Plastic and wood parts are cured at 150˚ F for 1 hour. Gun-Kote's basic cure is 1 hour at 325˚ F. Curing Gun-Kote at 400˚ F will make the coating harder and will cause the sheen to flatten. Time starts when the part has reached the cure temperature. Once the parts have baked for the recommended amount of time, you can turn the oven off. Allow the parts to cool slowly. Once the parts have cooled, they are ready to reassemble.

CLEANUP AND MAINTENANCE

Once all parts have been coated and they begin to cure, you are almost finished. You must clean any remaining coating out of the spray gun and mixing equipment. Any coating left in the sprayer will harden and render the tool useless. Dispose of any remaining coating in accordance with local laws and regulations. Clean paint cups and bottles with acetone. Once the cup or bottle is clean, fill it back up with clean acetone and spray it through the gun/airbrush. Spray the acetone until it runs clear through the gun.

If you are using Duracoat, follow the acetone with reducer. Wipe all surfaces with a clean rag with acetone on it. You may have to partially disassemble the gun/airbrush to remove all coatings. Refer to the manufacturer's instructions for proper assembly, disassembly and maintenance. It may sound cheesy, but if you take care of your equipment, your equipment will take care of you.

Maintenance includes keeping your preparation and spray equipment clean, refreshing blast media, and properly storing coatings. You also have to empty your compressors of moisture and your filters of oil and water. Coatings should be stored in a cool, dry place to prolong life.

STENCILS AND CAMOUFLAGE

Not only do modern spray-on finishes provide excellent protection, wear and abrasion resistance, lubricity, and heat maintenance, they can also be used for aesthetic appeal. With modern spray-on coatings your color palette is almost limitless. With basic materials, a little know-how, and some creativity, you can recreate any

camouflage or image on your firearm. Your only limit is your imagination. Because Duracoat and Cerakote are the two most popular spray-on finishes, we will discuss stenciling and camouflage with these two coatings.

The amount of material needed to complete most camouflages is minimal. In reality, the only new item(s) you will need are stencils. You can even make stencils out of paper or tape or special stencil making material. Other items include a pen or pencil, a hobby knife, some scissors, and a cutting board. There are also precut stencils available online for all of the most popular camouflages. If you are using Cerakote, you must make certain the stencil will handle the heat of the curing process.

The most important part of spraying camo is working with layers. All of the colors used in the camouflage will be stacked on the part's surface. Stencils will help you stack these layers and mask areas of the layer, preventing the application of a new color. Understanding how colors are layered to achieve a specific look and how stencils work will make applying different camouflages easier.

There are both "male" and "female" stencils (Figure 21). Male stencils mask off a specific area while female stencils will have a void in the center and mask the surrounding area. You will use both male and female stencils when applying camouflage or other finishes. You may find yourself switching from male to female stencils several times during the coating process.

The first thing you need to do is decide on the camo for your image. Once you have decided on a style you need to choose your color palette. Most camouflages require from three to six colors to achieve the desired results. Color selection can make or break a finish. Using complimenting colors will create a finish that is aesthetically pleasing, while the wrong colors will produce a finish that just doesn't look quite right. Some colors will change slightly when cured, so you may want to spray several test swatches so you can get a feel for how the colors compare to each other.

Next you will need stencils. You can either make them yourself or you can buy ready-made ones online. For small jobs you can probably get away with making your own. You can also have custom die-cut vinyl stencils made at a print shop.

Figure 20: A pistol with a two-tone finish.

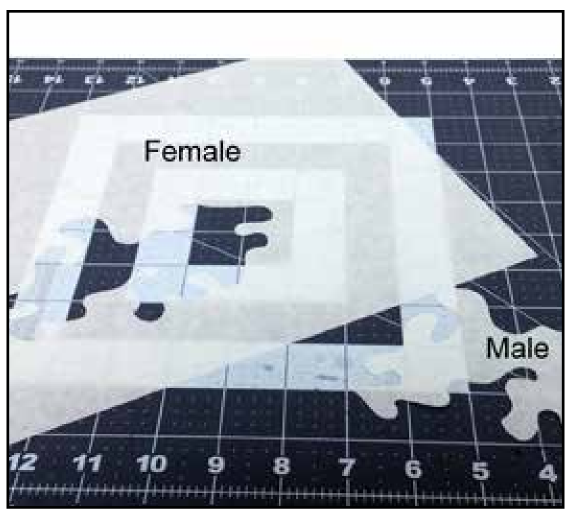

Figure 21: Male vs. female stencil.

Figure 22: Different types of stencils.

Whichever method you choose, make sure you have more than you need to achieve the desired coverage or if you mess up so that you have a backup. You can make your own stencils from stencil specific material, paper, tape, or anything else you feel will work for you. Artificial plants can be used for their leaves when creating hunting camo or fishnet pantyhose can be used to apply a snakeskin finish.

Once you have your idea, colors, and stencils, you can begin. Both Duracoat and Cerakote have specific instructions for applying stencils. Duracoat recommends letting parts cure for at least 2 – 3 hours before applying stencils. Every layer of stencils requires at least 2 – 3 hours of cure before a new layer of coating and stencils are applied. You can speed up the process by placing parts in an oven for 15 minutes at 115° F. Allow the part to cool before applying the next layer. Duracoat recommends applying all stencils and layers within seven days for proper adhesion.

Cerakote recommends flashing the parts for 15 minutes at 150° before applying stencils. Allow the parts to cool and apply stencils and another layer of coating. After every coat, you will have to flash the previous coat for 15 minutes. Cerakote recommends that all layers and stencils be applied and cured within 24 hours of the first layer.

To begin, you will have to spray a base coat onto the workpiece. The basecoat should completely cover the part and consist of one to two full layers. The base coat should also be properly cured before the application of stencils. Never try to apply a multi-layer basecoat.

Understanding layers now becomes extremely important. If you are using male stencils, when complete your basecoat will appear to be the top layer. If you are using female stencils, when complete the new color will appear as the top layer. You will have to plan your steps by color and stencil type to achieve the desired result.

Once your basecoat is applied and cured, you can begin laying stencils. Some stencils may span across multiple parts, so now would also be the time to assemble those parts. Assembly is not necessary but it will make the overall package look cohesive instead of each part looking similar without really matching.

Figure 23: Applying stencils.

Figure 24: Spraying stencils.

Stencils must lay flat against the part's surface with no wrinkles around the edges. You may have to lift the stencil and reapply it several times before it lays correctly. You can use popsicle sticks to press down on the stencils in hard-to-reach places. Because the coating particulate is so fine, if the stencil is not completely flat, coating will get underneath it and cause overspray. You do not want to fill the stencil with coating, you only want to spray enough for the color to change completely. Heavy spray will lead to a textured surface when the stencil is removed. Male stencils will produce hard, sharp edges while female stencils can be used to create hard edges and soft, blended edges.

Continue to apply stencils and coating until the desired results are reached. Allow the coating to flash or cure slightly before removing stencils. Sometimes the stencil will leave a sticky residue behind. This residue can be cleaned with mineral spirits. Spraying multiple colors and layers may produce a finish with an uneven sheen (semi-gloss and satin). You can apply a clear coat to even out the surface sheen. Make sure to remove any stencils or residue before applying the clear coat. Allow the parts to cure before final assembly.

TOUCH-UP

From time to time, you may get a run or debris on your workpiece, or general use will scratch or wear the surface. Duracoat, Gun-Kote, and Aluma-Hyde II can all be touched up. If Cerakote is scratched, chipped, wears off, or anything else, the coating will have to be completely removed. Cerakote will not bind to itself once it has cured.

For Duracoat, Gun-Kote and Aluma-Hyde II, touch-up is fairly simple. If you are applying a new top coat or fixing a small light spot or piece of debris, all you need is some 600-grit sandpaper. Use the sandpaper to rough the area intended to be sprayed. For dirt or debris in the finish, use a smaller piece of sandpaper folded several

Figure 25: Touching up the finish.

Figure 26: A beautiful camouflage finish.

times to work the dirt out of the finish. Clean the part and degrease it. Blow off any remaining dust or debris. Respray the affected area and allow it to cure as normal.

TROUBLESHOOTING

With so many steps in the coating process there is a great chance that at any time something could go wrong. Over time, coatings and hardener/catalyst will degrade and air lines will begin to fill with oil and water. Uncured Duracoat and Cerakote are also fairly reactive. Uncured silicon of any form will cause bubbles to form in Duracoat and mixing Cerakote in plastic containers will compromise the integrity of the coating.

The charts on the next few pages are general troubleshooting guides . Following the troubleshooting chart is a quick reference guide for spray on finishes. Contact the coating manufacturer if you cannot find a solution to your problem.

Problem	Possible Cause and Suggestions
The coating is blotchy.	• The pressure or material flow may not be adjusted correctly. Turn up the pressure or material flow. • The coating is too thick for the sprayer. Thin the coating. • You are moving the sprayer at an inconsistent speed or holding at varying distances. Move consistently and hold the sprayer at an even distance away from the part's surface.
The coating is thin and dry/rough.	• The material flow is too low or the pressure is too high. Adjust your material flow or turn the pressure down. • You are too far away from the workpiece. Move the sprayer closer.
The coating is runny.	• The workspace may be too cold or you have added too much reducer. Heat up the workspace. Remove the runny coating before it cures. Remix more coating with little to no reducer. • You are moving the sprayer too slowly. Speed up your movement across the part.
The coating is stringy (like spider web or cotton candy).	• The coating or hardener/catalyst is beyond its expiration date. • The coating is beyond its pot life. • Too much hardener or catalyst was used. Remove the coating before it cures. Remix new coating and respray.
The surface has orange peel or fisheye.	• The part was not properly degreased or was touched without gloves. • You did not use the correct cleaner for your coating. • There is oil and water getting into the air line. Remove the coating before it cures. Clean out your air lines and air cleaners. Thoroughly clean your spray gun and the parts. Only handle parts with gloves. Use only the manufacturer's recommended parts cleaner.
The coating is cured but it is chipping and peeling.	• The surface was not prepared correctly • The part's surface had oil or grease present. • The coating was not mixed correctly. Remove the coating by blasting with 120-grit aluminum oxide. Make sure the surface is rough enough to provide a good bond. Thoroughly clean the surface. Mix the coating to manufacturer's specifications.
The coating is not curing.	• If you are using a two-part coating, you may have forgotten to add hardener/catalyst. Remove the coating and respray. • If you are using air cure coatings, the curing room is too cold. Heat the room to between 80° and 90° F.
I keep getting dirt and debris in the finish.	• The spray area is too dirty. Remove the uncured coating. Thoroughly clean the spray area and recoat the part. • The coating was not properly strained. Remove the uncured coating. Strain the remaining coating and reapply.
The coating is not the correct sheen.	• If you are using a two-part coating, you did not mix the correct ratio of hardener/catalyst. • You sprayed the coating on too thick. Remove the old coating. Mix the coating ratio per manufacturer's specifications. Reapply the coating again, lighter.

Troubleshooting Guide

	Duracoat	Cerakote	KG Gun-Kote	Brownells Aluma-Hyde II
Coating Type	Two-Part Air Cure Urethane Base	Two-Part Thermoset Epoxy/Ceramic Base	One-Part Thermoset Epoxy Base	One-Part Air Cure Epoxy Base
Hardener/Catalyst/ Thinner/Additives	Hardener/ Reducer, Retarder, UV Hardener, Flattening Agent, Flex Agent, Accelerator	Catalyst	MEK or Ethyl Alcohol	Aluma-Hyde Solvent & Thinner
Mix Ratio	Optimum Ratio 12:1 (Satin Finish) 10:1 (Gloss Finish) 14:1 (Flat Finish) Coating to Hardener Reducer up to 20%	Optimum Ratio 18:1 (Satin Finish) 12:1 (Gloss Finish) 24:1 (Flat Finish) Coating to Catalyst	N/A Up to 20% MEK or Ethyl Alcohol	Optimum Ratio 5:1 Coating to Thinner
Parts Preparation	Abrasive Blast 120-Grit Aluminum Oxide 40 – 80 psi Hand Sand w/ Sandpaper or Scuff Pad/ Clean with TruStrip™	Abrasive Blast 100 – 120 Grit Aluminum Oxide 60 – 100 psi Hand Sand w/ Sandpaper or Scuff Pad/ Clean with Acetone	Abrasive Blast 100 – 120 Grit Aluminum Oxide 40 – 60 psi (stainless steel) 20 – 40 psi (carbon steel and aluminum)/ Clean with Acetone/ Heat parts to 100° – 125° F	Abrasive Blast 100 – 120 Grit Aluminum Oxide 60 – 100 psi Hand Sand w/ Sandpaper or Scuff Pad/ Clean with Acetone Heat parts to 100° – 125° F
Application Type and psi	Airbrush/HVLP 15 – 20 psi (Airbrush) 20 – 25 psi (HVLP) Wet	HVLP 20 – 25 psi Wet	HVLP 20 – 25 psi Light	Airbrush/HVLP 15 – 20 psi (Airbrush) 20 – 25 psi (HVLP) Light
Cure	Air Cure Dry to Touch 20 min. Parts Assembly 24 Hours Final Cure up to 6 Weeks	250° F for 2 Hours or 300° F for 1 Hour (all metals) 150° F for 2 Hours (all plastic and wood)	325° F for 1 Hour or 275° F for 2 Hours	Air Cure Dry to Touch 1 Hour Final Cure 7 – 10 Days
Cleanup	Duracoat Reducer	Acetone	MEK, Acetone	Acetone

This is a quick reference guide for spray-on finishes.

	Duracoat	Cerakote	KG Gun-Kote	Brownells Aluma-Hyde II
Layering/Stencils	Yes Stencils can be applied after 3 hours of air cure or 15 minutes at 115° F flash cure	Yes Stencils can be applied after 15 minutes at 150° F flash cure	N/A	N/A
Touch-up	Yes Allow parts to cure at least 24 hours; sand area with 600- to 1200-grit sandpaper; clean and respray	No	Yes Allow parts to cure; sand area with 600-grit sandpaper; clean and respray	Yes Allow parts to cure at least 48 hours; sand area with 600-grit sandpaper; clean and respray

NOTES

NOTES

Chapter 5: Modern Firearms Finishes II – Conversion Coatings

Conversion Coatings

Conversion coatings are coatings that use chemicals or a combinations of chemicals and electricity to change (or convert) the surface of the part into a different chemical. Conversion coatings add a layer of protection to the workpiece, typically in the form of an oxide (iron oxide, aluminum oxide, black oxide), or a phosphate. This added layer provides protection from the elements and chemical and corrosion resistance. Conversion coatings also provide aesthetic appeal and sometimes provide a great base for spray-on coatings. Conversion coatings are typically very thin (~.00001 in.), but with aluminum can be very thick (~.003). Conversion coatings often act as a passivation coating because the new layer is passive (does not react) to the environment or other chemicals. The most popular conversion coatings are bluing (both hot salt and nitre), black oxide, Parkerizing, and anodizing.

BLUING

Bluing is a treatment that causes rapid oxidation, creating a thin surface layer of oxide on ferrous metals and producing a bright blue (nitre) or dark blue, blue/black finish. There are two basic methods of bluing: hot and cold. The two types vary in the temperature of the reaction and the many different chemicals used. Bluing provides some corrosion resistance but is considered mostly an aesthetic finish. Hot bluing provides more protection than cold bluing, but neither method produces any scratch or wear resistance.

Cold bluing is more of a coloring process. Typically, selenium dioxide is used to color the steel dark gray to black. It offers little to no protection or corrosion resistance. It is also very difficult to apply evenly over large surfaces. Cold bluing is usually reserved for small parts or touch up. Cold bluing is easily accomplished with minimal materials.

All that is needed to cold blue is a cleaner (alcohol will work), fine steel wool, and a bluing pen or bluing solution. Because there are so many different alloys of steel, different cold blue solutions are available. The area must first be cleaned with steel wool. This will remove any surface oxides that build up naturally and prevent the bluing from taking. Rub the area with the steel wool until it is bright. Clean the area with alcohol and wipe it dry. Apply the bluing solution to the area through the pen or with a Q-tip or cotton swab. Allow the solution to work for about a minute and then rinse it off with clean water to stop the reaction.

Figure 1: Cold bluing.

Figure 2: Hot bluing equipment.

Rub the area with steel wool once again. The area may only be lightly blued at this point. You may have to repeat this process several times until you reach the desired finish. Apply a small amount of oil to the area to set and protect the finish.

Hot bluing is much more involved and requires a considerable investment. Cost puts it out of reach for most hobbyists, so hot bluing is usually reserved for professional shops. Hot bluing typically uses an alkali salt solution at elevated temperatures to create the protective layer. The layer of oxide is very thin (.00001 in.) and will not interfere with tolerances at all. Also, because the layer is so thin, it will retain the same surface finish as the part. What this means is that if the part is polished, the bluing is bright and shiny; and if the part is rough, the bluing will be deep and dull. Hot bluing produces a surface oxide that is more corrosion-resistant than the cold method but is still not scratch- or wear-resistant.

The tool and material list for hot bluing is much more substantial than cold bluing and requires much more time. Surface prep constitutes for most of the labor involved. The additional time is waiting for the salts to heat up and the parts to turn. Setting up your shop for hot bluing will require an investment of several thousand dollars. Brownells offers a complete Bluing System Kit ($2,300), which includes everything you need to start hot bluing.

The kit* comes with all of the following:

- Tanks (4)
- Stands (4)
- Burners (3)
- Parts baskets (2)
- Thermometers
- Cleaners
- Salts
- Water-displacing oil
- Solvents and cleaners
- Tank covers
- Personal safety gear (face shield, gloves, and apron)
- Extra additives
- Bluing instruction book

**Does not come with propane tank(s).*

Figure 3: Blued finish.

To begin, the parts are first prepared. The level of preparation is dependent on your desired look. For a beautiful, bright, shiny finish you will have to polish the parts. For a dull finish all you have to do is blast the parts with aluminum oxide. Other surface finishes would include bead blasting (satin finish) or brushing (semi-gloss finish). Whichever finish you decide to use should be consistent throughout the part. Any scratches or unevenness will be magnified by the bluing.

When you are satisfied with the surface preparation of the part, you can begin preparing the tanks. There are four tanks, each with its own purpose. One tank will hold the bluing solution, another will hold the cleaner, and the last two will hold hot and cold water for rinsing. The bluing, cleaner, and hot water tanks will all be heated to different temperatures. The bluing tank should be around 300° F while the cleaner and hot water tanks should be heated to around 180° F.

You will need to mix the salts and cleaner/detergent per manufacturer's recommendations. The solids in the salts and cleaner must be fully dissolved before bluing can begin. Make sure the parts are clean and free of oil. Thoroughly clean and degrease parts with a cleaner that will not leave a residue behind (like acetone). You can place smaller parts in the parts baskets and hang larger parts with wire in the tank.

Start by soaking the parts in the tank with the cleaner for 15 – 20 minutes. Remove the parts from the cleaning tank and rinse them in the cold water tank. Thoroughly rinse the parts to remove any trace of the cleaner. Any cleaner left on the part's surface will cause streaking in the finish. Rinse the parts for 2 – 3 minutes.

Remove the parts from the rinse tank and allow them to drip dry. If there is any cold water trapped in the parts when you dip them into the salt tank, the liquid will pop and bubble out of the tank. This can be very dangerous. Once you are satisfied that the parts are dry enough, you can put them into the salt tank. You should also be careful when dipping barrels into the tank. Lower the barrel into the tank one end at a time to prevent the solution from popping. Let the parts soak 20 – 30 minutes. Lightly swish small parts around to assure full coverage. Check the parts after about 20 minutes. If the parts are the correct color, you can take them out. If they are not, you should leave them in for longer. Some steel alloys high in nickel can take up to an hour to change.

Once the parts have reached the desired color, remove them from the salt tank and place them in the hot water tank. The hot water will stop any further reaction and set the coating. Remove the parts from the hot water after a few minutes and place them in the water-displacing oil. The water-displacing oil will force water out of the part's surface and provide a thin layer of moisture resistance. After the parts have cooled, you can take them out of the water-displacing oil and dry them off. They are now ready for reassembly.

The nitre bluing process is the same as the regular bluing process. The only things that are different are the type of salts (potassium nitrate and sodium nitrate) and the temperature (600° F+). The parts must be watched constantly because there is a very small window during which the reaction happens. The high temperature of the process also limits it to small or noncritical parts because it could affect the part's heat treatment.

BLACK OXIDE

Black oxide is a type of conversion coating used to create a layer of oxide that is somewhat corrosion-resistant. Black oxide produces a deep black finish that also minimizes reflection. The black oxide process converts a thin layer of the part's surface into magnetite, which is an oxide of iron. The new surface is very porous and provides even more corrosion resistance when impregnated with oil. Black oxide can be applied to ferrous metals, steel alloys, copper and copper alloys.

Black oxide can be applied in three different ways: hot, mid-temperature, and cold. Hot black oxide uses sodium hydroxide, nitrates, and nitrites in a bath solution at 285° F to create the reaction. Mid-temperature black oxide is similar to hot but is produced at a much lower temperature (105° – 120° F). The mid-temperature process is better suited for hobbyists and shops because the lower temperature processing does not cause the solution to boil, reducing the risk of exposure to the caustic fumes. Cold black oxide is similar to cold bluing in that it is more of a surface dye than an actual conversion coating. Instead of creating a layer of magnetite like hot and mid-black oxide, cold black oxide deposits a layer of a copper selenium compound onto the part's surface. Cold black oxide makes coloring small parts easy and simple for anyone because it is accomplished at room temperature (70° - 80° F).

The hot black oxide process is very similar to the hot bluing process. Outside of the chemicals used to create a reaction, most of the materials and tools are the same. A respirator should be worn while working with hot black oxide. Because the coating is so thin (.00004 in.), it will take on the sheen of the surface finish.

Figure 4: Black oxide-coated parts.

Parts preparation is also similar to bluing, media blasting, bead blasting, brushing, or polishing. The parts are dipped into four different tanks, each with a different liquid. The first tank is filled with an alkaline cleaner. The parts are submerged for 15 – 20 minutes. Once the parts come out of the first tank, they go into a rinse tank filled with water to remove any traces of cleaner. Rinse the parts for 2 – 3 minutes and remove them from the rinse tank. Allow most of the water to drip off before placing them in the caustic soda (sodium hydroxide/lye), which should be 285° F. The caustic soda will convert the surface of the part and chemically bond with it, creating a porous surface. After about 20 minutes, remove the parts and dip them in the sealer tank, which contains any quality oil. The oil is absorbed by the new porous surface and provides greater corrosion resistance. Mid-temperature black oxide is applied in the same manner as hot black oxide except the caustic soda solution is around 105° – 120° F.

Figure 5a: Brownells Benchtop Parkerizing Kit.

Figure 5b: Parkerized parts.

PHOSPHATE CONVERSION COATINGS

Phosphate conversion is a coating process for steel and other metals. It uses phosphoric acid and phosphate salts to convert the part's surface to crystalline phosphates. The new surface provides corrosion resistance as well as lubricity and a suitable surface for paint or other coatings because of its porosity. There are three main types of phosphate coatings: manganese, iron, and zinc. Manganese phosphates are used both for corrosion resistance and lubricity. Iron phosphates are typically used as a base for further coatings or paint. Zinc phosphates are used for corrosion resistance (phosphate and oil), a lubricant base layer, and as a paint/coating. Manganese phosphates are only applied by submersion, while iron and zinc phosphates can be applied by immersion or by spray.

The most popular phosphate coating for firearms is Parkerizing, which is an improved zinc/manganese process. Parkerizing cannot be applied to nonferrous metals like aluminum or copper. Also, it cannot be applied to steel alloys high in nickel or stainless steel. The best surface preparation for parts intended to be Parkerized is aluminum oxide blasting, which speeds up the process and reduces the cost (no time or money into bead blasting, brushing, or polishing).

The tool and material list for Parkerizing application is also minimal, which makes it ideal for professional shops and hobbyists alike. Brownells sells the Benchtop Parkerizing Kit, which includes all the chemicals, tanks, and safety gear you'll need, right down to wire for hanging the parts on. All you have to add is a heat source and a supply of clean water. The kit is available in both manganese phosphate and zinc phosphate. The manganese kit ($340) produces a slightly thicker, more porous coating that is dark gray to black and makes a great stand-alone finish. The zinc kit ($305) produces a slightly thinner fine-grain surface that is light to medium gray and makes a perfect base for most spray-on coatings. The zinc kit also requires less solution, which makes it more economical.

The application process is fairly simple. Once the parts are prepped and clean and degreased, they can be immersed in the Parkerizing solution, which is heated to 190° – 210° F. The parts may take anywhere from 5 to 45 minutes to change, based on chemical makeup. Bubbles will rise from the part's surface while the chemicals are still reacting. Once the bubbles stop, the part is done. Remove the parts from the solutions and rinse them with hot water. Once the parts are cool, you can begin reassembly. You can also apply a thin layer of oil to the parts for an added level of corrosion resistance.

ANODIZING

Anodizing is a process that creates a protective layer of oxide on some metals. The anodizing process consists of an electrical circuit that is comprised of the part (anode/positive electrode), an electrolyte (conducts electricity) solution (typically a water/salt solution or sulfuric acid), a cathode (negative electrode), and a current generator. The layer of oxidation is meant to provide the metal with both corrosion and wear resistance. The layer of oxidation can be tailored for thickness as well as be dyed for cosmetic effects. Aluminum, titanium, and magnesium can all be anodized. Iron and steel alloys cannot be anodized and will react unfavorably (creating rust and pitting).

The anodizing process "grows" the layer of oxide on the part's surface by passing direct current through an electrolytic solution. The part is submerged in the solution and acts as the anode (positive electrode). A cathode (negative electrode) is also submerged in the solution. The current causes hydrogen to be released at the cathode, and oxygen to be released from the surface of the part, causing the surface oxide to grow. The process is the same for aluminum, titanium, and magnesium; the only things that change are the chemicals and ratios used and the current/voltage and temperature.

The most common type of anodizing is performed on aluminum. Aluminum anodizing is broken down by finish specifications and the most widely used is U.S military specification MIL-A-8625. This spec is broken down into three main types based on chemicals used and finished results: Type I, II, and III. Type I uses chromic acid as its solution and produces a finish that is .000002 in. – .00007 in. thick and not very porous. Chromic anodizing is thinner, softer, and more ductile, and in some cases, "self-healing"† , but does not take dye very well. Type I also differs from Type II and III in current application. Type I uses constant current at its highest specification, while Type II and III use varying current that must gradually increase to continue to "grow" the layer of oxide.

Figure 6: Anodized aluminum parts.

Type II and III both use sulfuric acid as their reaction chemical. The difference between II and III is the thickness of the coating. Type II is around .00007 in. thick and Type III is around .001 in. thick and very porous and is commonly black. It is so porous, in fact, that it may allow air and other chemicals to reach the surface. This is why Type III must be sealed after anodizing. This is also what makes Type III perfect for dying. The increased thickness of the coating increases its wear and corrosion resistance and also its ability to retain lubricant or PTFE (Teflon™). The anodized layer grows both down into the surface and up from the surface at an equal amount. This means the anodizing will add half the thickness of the coating to the part on each surface. If the anodizing is .001 in. thick, it will add .0005 in. of dimension to each surface of the part.

Surface prep is similar to bluing and black oxide in that the anodizing will retain the surface's finish profile. This means that a rough-blasted finish will remain rough and a polished finish will make the anodizing shine. Whichever finish is used, you must assure that it is consistent. Any imperfections in the surface will be magnified by the dye. The surface must also be clean and degreased.

†*When scratched, the natural layer or oxide that is created by exposure to air will bond to the artificially oxidized layer and seal the scratch.*

Because of the hazardous chemicals used and caustic vapors produced, the anodizing process is beyond most hobbyists. For the average gunsmithing shop, the biggest factor in deciding whether or not to anodize is need. There is not much need for the average gunsmith to invest in anodizing equipment if he/she will only use it a couple of times a year. There are DIY kits available for small-scale projects and limited run production for around $1,000. The kits come with most of the things you will need:

- Tanks with lids
- Enamel tanks with lids (for dying and sealing)
- Glass thermometer
- Rinsing sprayer
- Mist balls*
- Mist suppressant*
- Anodizing sealant
- Aluminum degreaser
- Deoxidizer
- GP plates
- Agitator pump
- Aluminum strips
- Constant current power supply
- Instructions and tips
- Baking soda (for cleaning up any acid spills)
- Safety equipment (masks, apron, glasses, gloves)

You will need to supply your own sulfuric acid in the form of battery acid (available at any auto parts store) and your own ceramic heaters. The size of your part is limited by your tank size. Most kits are capable of being upgraded to larger tanks for larger parts.

**The mist balls and suppressant are used to control the caustic fumes that are released by the reaction. These two components make it possible to anodize in small scale quantities without having to adhere to environmental regulations.*

Figure 7: NiB-X and NP3 parts.

The process is fairly simple and is similar to the other conversion coatings. There are four tanks, each with their own chemical. Prepared parts are first dipped into a container with degreaser that is near boiling. The parts are allowed to soak in the degreaser for 15 – 20 minutes. The parts are removed from the cleaning tank and dried and then moved to the anodizing tank, which is heated to around 140° F. The time the parts will sit in the anodizing tank will vary with the desired results. The alloy of the part, the concentration of the sulfuric acid solution, and the current will all affect the finish.

Once the desired finish is reached, the parts come out of the anodizing tanks and go into the dying tanks, which are near boiling. The parts are allowed to soak in the dye until the desired hue is achieved. The parts are removed from the dye and placed into the sealer, which is around 140° F. The part is allowed to soak in the sealer for up to 30 minutes. Once the parts are removed, cool and dried, they are done.

NICKEL ELECTROPLATING AND ELECTROLESS PLATING

Nickel electroplating and electroless plating are the processes of depositing nickel or nickel alloy layers onto base metal that is between .0009 in. and .004 in. thick. The plating is performed in one of two ways: electroplating (electricity) and electroless (chemical) plating. Nickel plating is used to provide a very durable corrosion- and wear-resistant layer used to protect the base metal (iron, steel, copper, brass and aluminum). Nickel coatings can also include lubricants and PTFEs that can be used to reduce friction. They can also be used as aesthetic coatings, producing a yellowish/silver to almost chrome-like finish, depending on surface finish.

Electroplating, as its name implies, uses electric current to bond nickel and other elements to metal surfaces. Like anodizing, the part acts as the anode immersed in an electrolytic solution. A nickel cathode is used and when current is applied, the nickel begins to atomize and is attracted to the anode and bonding.

Electroless plating, like its name implies, does not involve electric current. Electroless nickel relies on a chemical reaction to deposit nickel onto the part's surface. The addition of other chemicals can enhance the mechanical properties of the nickel plating making it more abrasion-resistant or lubricious. Some popular nickel coatings include nickel boron and NP3. Nickel boron is an electroless process that includes the addition of boron. NP3 is also an electroless process, but instead of boron, it relies on Teflon for its friction reduction characteristics.

The electroless plating process is similar to bluing in that the part is submerged in a hot solution to create the reaction. The electroplating process is similar to anodizing in that they both use electrical current in a solution to cause a reaction. There are also many variants of nickel coatings within the two types, based on chemical content.

Like anodizing, nickel plating is beyond the capabilities of most hobbyists, and is not requested enough to justify in a gunsmithing shop. Name brand (NiB-X or NP3) nickel coatings are usually proprietary formulas for industrial nickel coating processes. There are DIY kits available for both electroless and electroplating, with everything you need for around $400 each. The kits are used for plating mostly decorative nickel. The coating does provide some corrosion and wear resistance but cannot compete with modern performance industrial nickel coatings.

FERRITIC NITROCARBURIZING

Ferritic nitrocarburizing is a case-hardening treatment that diffuses nitrogen and carbon (mostly nitrogen) into the surface of ferrous metals. The diffusion process is accomplished at temperatures near 1,100° F, which creates an extremely hard, wear-resistant surface that also reduces friction. The process does not warp or distort parts like other hardening processes, either.

Nitrogen and carbon are introduced one of three ways: gas, ion/plasma, and salt bath. These

Figure 8: Tenifer-coated pistol slide.

Figure 9: PVD-coated parts.

processes are mostly used on low carbon and low alloy steels, but can also be used on medium and high-carbon steels, titanium, aluminium, and molybdenum. The gas process introduces a heated workpiece to a nitrogen-rich gas, such as ammonia. The plasma process uses electric fields to ionize the surrounding gases. The salt bath process introduces parts to a solution of nitrogen salts (cyanide salt).

Because ferritic nitrocarburizing is a case-hardening treatment, the surface does not build up. Instead, the process diffuses a layer or hardened case from .0005 in. to .025 in. deep depending on the alloy being treated. After the carburizing process, the parts can be Parkerized or processed with another coating for an added layer of protection and performance.

Nitrocarburizing requires specialized equipment and materials, which puts the process out of reach for hobbyists and gunsmithing shops. Environmental and safety factors put it out of reach for most manufacturers. Ferritic nitrocarburizing is also known as nitriding, or by its many trade names: Melonite®, Tenifer®, Isonite®, WASP, NiCorr, and others.

PVD COATINGS

Physical vapor deposition is a process of coating a metal part with a ceramic-like, metal coating. PVD coating is a type of electroplating process but differs from anodizing and nickel plating in that it is done under vacuum and not in an electrolytic bath. PVD coatings are often harder and more corrosion-resistant than most other coatings. Most PVD coatings have high temperature and good impact strength, excellent abrasion resistance, and are so durable that

protective topcoats are almost never necessary. PVD coatings can also be tailored to reduce friction. Most PVD coatings have a lower coefficient of friction than other coatings (while still being corrosion- and wear-resistant). Popular PVD coatings are TiN (titanium nitride), AlTiN (aluminum titanium nitride), and DLC (diamond-like carbon).

The PVD process uses the part as the anode and a target (metal ingot) as the cathode. The target is vaporized in a variety of ways including heat, electricity, lasers, plasma, and electron bombardment. The vaporized material is attracted to the anode and deposits on its surface at around .00004 in. thick. The temperatures involved in the process are high enough to fuse the atomized metal, creating a uniform coating. The coating that is applied to the part will vary with the type of deposition used and the elements involved.

The process is beyond hobbyists, gunsmith shops, and most manufacturers. The process is sometimes finicky and requires specialized equipment to apply correctly and to test that the application was performed correctly. There is also a degree of experience that is required when working with PVD coatings. They are "line of sight" coatings, which means that if the surface is not directly facing the target and its atomized particles, it will not be coated. Intricate parts become very difficult to coat and must be moving (rotating or spinning) inside of the vacuum chamber. Because of the wide range of mechanical properties PVD coatings offer, they are quickly becoming one of the most widely used in the firearms industry.

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Chapter 6: Hydrographics

Introduction

Customizing the look of your project through refinishing allows you to create a truly unique-looking firearm. With a variety of colors, patterns, and images to choose from, refinishing offers the freedom to personalize your firearm in a way that reflects your own style and taste. While there are professional companies who provide firearm refinishing, hydrographic do-it-yourself kits give you the opportunity to customize your rifle in the privacy of your own home.

In this lesson, you will learn to customize the finish of a rifle using the Dip Stick™ Hydrographic Dipping Kit. This kit enables you to personalize a firearm using primer, paint, and specialized film in a process that can be done easily, with a few basic supplies.

Kit Contents

The tools you received are shown in Figure 1. The part numbers and descriptions appear next to the figure.

Check the material that you received against the parts list to make sure that your kit is complete. If any part is obviously defective or has been damaged during shipment, please return it to Sonoran Desert Institute for replacement. Also, notify Sonoran Desert Institute if any part is missing from your kit.

Your kit contains the following:

- 12 oz. can of Dip Stick™ Primer/Paint
- 12 oz. can of Dip Stick Activator
- 12 oz. can of Dip Stick Clear Coat
- 2 meters of Hydrographic Film
- 1 pouch – Cut Thru Wipe
- 1 pouch – Adhesive Promoter Wipe/Tack Cloth
- 2 sets of gloves
- 1 scuffing pad
- 1 dust mask
- 1 Instruction Manual

Other items you will need but are not included: masking tape, PVC pipe, extra gloves, dip container.

Figure 1: The tools included in your kit.

** Please note that from time-to-time, kits may be unavailable. Should this occur, we will substitute an appropriate kit that will meet the objective of this lesson. DipWizard and DipStick are essentially the same product.*

CHOOSING A DIPPING CONTAINER

The first step in the process is to choose the correct size dipping container that will be used to dip your project. Make sure that the container is wide and deep enough to completely submerge the items that you will be dipping. It is necessary to have ample space between the sides so you will be able to move the item freely. More important, though, is the depth of the container — it is imperative that you can completely submerge the item during the dipping process. Keep in mind, as well, there will be water displacement, so be sure water will not spill over during the dipping process. A ridged container is best so that the water weight will not bow out the sides.

You will be able to find a variety of plastic containers at your local big box stores. They will range from about $10 and up.

Figure 2: Should you become a professional arms coater, you would invest in a large dip tank like this.

If you plan to complete a lot of dipping projects, you can invest in a professional dip tank from a retailer (Figure 2), or you can build your own dip tank with items from the hardware store for less than $300 (Figure 3).

Figure 3: A uniquely created dip tank system using old military storage boxes, heater, PVC piping and shower heads.

Surface Preparation

Make sure that the item you are dipping can go into water. Do not dip any electrical parts or items that cannot be completely submerged in water for 10 seconds. Do not dip any items that absorb water.

It is important to properly prepare your project. Whether your item is metal, plastic, or even an animal skull, it must be prepared properly prior to the dipping process. Use the scuff pad included in your kit to dull the surface so the paint will adhere to it. Use grease or wax remover, alcohol, or Wizard Wash to clean the surface, making certain that you have a grease-free, clean, and dulled surface. If you are planning to dip any metal parts, use the Cut Thru Wipe included in the package, as it insures a good, clean finish. Prior to painting, use the enclosed Tack Cloth on all your items to be dipped; this wipe allows the item to grab the paint.

Pro Tips. *If you are preparing a gun part made of plastics and/or composites, it is recommended that you use an adhesion promoter. They are available through many manufacturers such as Dupli-color and Bulldog. They can be in liquid or in aerosol form. Adhesion promoter acts as a clear primer/sealer to the object and creates a better "bite" for the paint.*

Figure 4: Step 1 - Prepare the surface by sanding.

Figure 5: Step 2 - Next, tape off sensitive areas.

Figure 6: Step 3 - Wipe off surface with tack cloth.

TAPING

Any area that you don't want dipped will need to be taped. It is a good idea to tape the inside area of the gun so that all the removed parts will fit properly upon reassembly.

PAINTING

Using the Dip Stick™ paint, spray your project until you completely cover all the exposed areas you wish to be dipped. For best results, apply two coats of base coat paint and let dry for 4–6 hours in temperatures above 65°. You will want to dip your project within 24 hours of painting. As the paint hardens, the dipping process can become more difficult.

PREPARING THE FILM

Once the size of your project has been determined, measure the amount of film you will need for your project. Make sure to take into account curves, rounded areas, 3-dimensional areas, and unique angles. Use additional film if there is any question; it is better to have a little waste than to not have enough to dip your project.

There are two easy methods for dipping: taping, or building a dam system.

Tape. Using ½ in. masking tape, outline your measurements with tape. Once you have taped completely around your measurements, cut the outside perimeter of the masking tape so that the tape is part of your dipping project. Make diagonal cuts on all corners as well as halfway between the corners.

Figure 7: Step 4 – Paint your entire project.

Figure 8: Tape system.

Figure 9: PVC dam system.

PVC Dam System. This is the superior method for dipping without a professional tank. Purchase two sticks of PVC (½ in. or ¾ in.) and four respectively sized 90° slip joints. Cut your PVC into variable lengths (10 in., 12 in., 16 in., etc.) so that you can build a frame that would be appropriate for the item you wish to dip. This frame will float and be used for your dipping area. You will cut your film ½ in. – 1 in. smaller than the dimensions of the frame. With the frame floating in your water (approximately 85°), lay your film into the frame and let it hydrate for 1–2 minutes. With a dry finger, tap or blow any air bubbles that might be trapped under your film.

Keep water away from your film. All hydrographic film is water soluble and should be kept dry and away from high humidity environments. If the film gets wet prior to dipping, the film will not process properly.

Dipping

Use tap water that is between 80–90° and fill your chosen container with enough water to submerge your project entirely.

Place your prepared film in the water with the proper side down in the water. If you are not sure, dampen your thumb and index finger and hold the film — the sticky side will go face down in the water.

Let the film float on the water for about 2 minutes prior to spraying activator. Spray an even coat of activator on the film (Figure 10). Make several passes and use different spray patterns to insure an equal amount is on all the film. Once the activator has been applied, you will notice that the film will expand and then stop. Don't worry that the film expands, this is normal. When the film is completely activated the film will have a glassy look.

Figure 10: Activating the film.

Figure 11: Begin dipping your project.

Figure 12: Completely cover your project.

Figure 13: Slowly remove your project from the solution.

ZERO IN

NOTE

If reusing your dip tank for several projects and your film will not adhere to your project, you may have too much activator floating on the surface. Empty the tank, clean thoroughly and fill with fresh water.

Depending on what you are dipping, handling your project is important. DO NOT HOLD AN AREA ON YOUR PROJECT THAT NEEDS TO BE DIPPED. There are several ways to avoid this. You can make tape handles on the side that will not be dipped, or you can use screws and piano wire to make a holder; you can get very creative with this process.

As you prepare to dip your project, submerge your project at a 30° angle to avoid air pockets (Figure 12). Keep your project at the same angle as you submerge it slowly and consistently. Once the project is completely submerged, slowly shake the project to dissolve the excess dip in the dipping container. Remove your project from the water.

You will notice that your project has a milky residue on it. Do not rub it at this time. After about 60 seconds, rinse your project in a clean, gentle spray of water (Figure 14). This process will take several minutes and you can slowly increase the water temperature as you do this process. Gently rub the project until the slimy feeling is gone. **It is imperative that you rinse the item thoroughly.** If the residue (called PVA) is not completely removed, there is a chance of a chemical reaction with your clear coat, which can create an orange peel look. Once thoroughly rinsed, let your project dry completely before moving to the next step.

CLEAR COATING

With your project completely dry, prepare a dust-free area where you can spray. Be sure to clear coat in a temperature greater than 65°.

Apply your clear coat as you did the paint, evenly as possible. You can apply as many coats of clear as you like, though it is recommended that three coats be applied. Let each coat dry 15 minutes prior to an additional application.

Once you are done clear coating, let the item cure prior to use. **Clear coat can take several days to fully harden; don't rush this process or you will see finger smudges on your project.**

If you need guidance on this process, check out the videos a www.dip123.com/pages/galleries/instructional-videos.html.

Figure 14: Rinse with a gentle stream of water.

PAINT AND PATTERN OPTIONS

DipStick carries a myriad of patterns to choose from as well as several base coat paint colors. You might try different combinations of paint and film patterns to produce your idea look. This process is simple but takes patience and a clean work environment. Do not go to the trouble of dipping your gun, only to have it covered in dirt and dog hair before the process cures.

ADDITIONAL PRODUCTS

Dip Stick provides you with enough paint, primer and activator to do many projects, but you may still need more film or want to use other patterns. A few pattern examples are shown in Figure 15 or go to Dip Stick's website at www.dip123.com to see the other patterns that are available.

Figure 15: A small sampling of patterns available from Dip123.com

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